THE SCHOOL OF PUBLIC POLICY PUBLICATIONS

SPP Research Paper

Volume 14:1 January 2021

BENEFIT-COST ANALYSIS OF FEDERAL AND PROVINCIAL SR&ED INVESTMENT TAX CREDITS

John Lester[*]

SUMMARY

There is a sound public policy case for subsidizing research and development. When firms perform R&D, they create knowledge that allows them to introduce new products, improve existing goods and services or reduce production costs. However, some of the knowledge created inevitably leaks out or spills over to other firms, allowing them to reap benefits from R&D without performing it themselves. These spillover benefits improve Canada's overall economic performance, but firms do not consider them when deciding how much to invest in R&D, so a subsidy to encourage more R&D is the right policy response.

When deciding how much to subsidize R&D, governments should consider both the benefits and costs of the subsidy. The benefit to Canadians from subsidizing R&D is determined by the knowledge spillovers. While the additional R&D induced by a subsidy is also a benefit, capital and labour are assumed to be fully employed so this output gain is offset by losses in other sectors when taxes are increased, or spending is cut, to finance the subsidy.

The analysis of benefits and costs incorporates the assumption that market signals result in R&D being performed as efficiently as possible. A subsidy interferes with market signals by lowering the hurdle rate for a profitable investment. As a result, subsidies allow firms to undertake R&D projects with lower commercial value but the cost to society of performing the R&D remains

[*] Executive Fellow, School of Public Policy, Calgary, Alberta and Senior Research Associate, Centre for the Study of Living Standards. E-mail: john.lester@sympatico.ca.

http://dx.doi.org/10.11575/sppp.v14i.70039 www.policyschool.ca

the same. This efficiency loss becomes a larger share of the spillover benefit as the subsidy rate rises.

Raising taxes to finance an R&D subsidy does not have a direct negative effect on Canadians' overall income if the revenue from the tax – the subsidy -- stays in Canada. However, some of the subsidy will be transferred to foreigners, which reduces the income of Canadians. This transfer occurs through higher profits of R&D performers that are foreign-owned and through lower export prices of products and services developed with subsidized R&D.

Finally, expenses incurred by governments to administer the program and by firms to comply with its eligibility requirements represent a cost to society. Resources devoted to these activities could have been used productively elsewhere.

Governments in Canada subsidize R&D performed by small firms at a much higher rate than R&D performed by larger firms. The federal government provides a 15 per cent tax credit for R&D performed by large firms while all small and medium-sized Canadian-controlled private firms performing R&D receive a 35 per cent subsidy in the form of a refundable tax credit. Provincial programs reinforce this bias, raising the average small-firm statutory subsidy rate on eligible spending to 42 per cent and the large-firm rate to 20 per cent. In addition, about 2,000 small firms top up the SR&ED incentive, which is available to all firms performing R&D, with targeted assistance from the Industrial Research Assistance Program (IRAP), raising the subsidy rate to almost 60 per cent on average for these firms.

Subsidizing small firms at a higher rate than large firms would be good policy if small firms generated larger knowledge spillovers. However, research by Myeongwan Kim and myself (2019) shows that the firms eligible for the 35 per cent credit generate much smaller spillover benefits — approximately 20 per cent — than the larger firms claiming the 15 per cent credit, which generate spillovers of just over 50 per cent.

The benefit-cost analysis shows that the federal large-firm credit generates a net benefit for Canadians. Provincial R&D support programs add to this net social benefit. Alberta would obtain a net benefit by reinstating a subsidy for R&D performed by large firms. In contrast, the federal enhanced credit fails a benefit-cost test because of relatively small spillovers and high costs associated with applying for the credit. Provincial programs increase the social loss from subsidizing R&D performed by small firms.

There would be a substantial income gain if the federal government increased its large-firm credit rate to 20 per cent and reduced its small-firm subsidy rate to 10 per cent. The income gain would be further increased if provincial governments adopted a 10 percent subsidy rate for all firms. With this change, the combined federal-provincial statutory rate would be 28 per cent for large firms and 19 per cent for small firms. Thousands of small firms would continue to top up the generally available subsidies with grants from IRAP, which could raise the subsidy rate to about 40 per cent for these particularly promising firms.

INTRODUCTION

There is a sound public policy case for subsidizing research and development. When firms perform R&D, they create knowledge that allows them to introduce new products, improve existing goods and services or reduce production costs. However, some of the knowledge created inevitably leaks out or spills over to other firms, allowing them to reap benefits from R&D without performing it themselves. These spillover benefits improve Canada's overall economic performance, but firms do not consider them when deciding how much to invest in R&D, so a subsidy to encourage more R&D is the right policy response.

When deciding how much to subsidize R&D, governments should consider both the benefits and costs of the subsidy. The benefit to Canadians from subsidizing R&D is determined by the knowledge spillovers.[1] While the additional R&D induced by a subsidy is also a benefit, capital and labour are assumed to be fully employed so this output gain is offset by losses in other sectors when taxes are increased, or spending is cut, to finance the subsidy.

The analysis of benefits and costs incorporates the assumption that market signals result in R&D being performed as efficiently as possible. A subsidy interferes with market signals and causes R&D to be performed less efficiently. The loss in efficiency can be illustrated by considering how the subsidy affects the commercial rate of return on the additional R&D performed. By lowering the hurdle rate for a profitable investment, subsidies allow firms to undertake R&D projects with less commercial value without reducing the cost to society of performing the R&D.

Raising taxes, or cutting spending, to finance an R&D subsidy does not have a direct negative effect on Canadians' overall income if the revenue from the tax -- the subsidy -- remains in Canada. However, some of the subsidy will be transferred to foreigners, which reduces income in Canada. This transfer could occur in two ways. First, since some firms eligible for the subsidy are owned by foreigners, profits earned on subsidized investment in R&D will benefit non-Canadians as well as Canadians. Second, some of the subsidy will be passed on to the consumers of the products and services developed using the subsidized R&D in the form of lower prices. These products will be sold on domestic and world markets, so some of the subsidy will be transferred to foreigners.

Finally, expenses incurred by governments to administer the program and by firms to comply with its eligibility requirements represent a cost to society. Resources devoted to these activities could have been used productively elsewhere.

Governments can in principle set the subsidy rate to maximize its net benefit. This possibility arises if, as seems likely, increases in the subsidy rate generate benefits that are a constant share of the additional R&D induced by the subsidy and costs that are a rising share of the additional R&D. This relationship causes the net benefit to have an inverted "U" shape: it initially rises along with the subsidy rate but eventually declines

[1] The knowledge created also benefits non-Canadians, but the benefit-cost analysis is focused on the net benefit for Canadians.

as the private return on R&D continues to fall and transfers of the subsidy to non-Canadians continue to rise.

Governments in Canada subsidize R&D performed by small firms at a much higher rate than R&D performed by larger firms. The federal government provides a 15 per cent tax credit for R&D performed by large firms while all small and medium-sized Canadian-controlled private firms performing R&D receive a 35 per cent subsidy in the form of a refundable tax credit. Provincial programs reinforce this bias, raising the average small-firm statutory subsidy rate on eligible spending to 42 per cent and the large-firm rate to 20 per cent. In addition, about 2,000 small firms top up the SR&ED incentive, which is available to all firms performing R&D, with targeted assistance from the Industrial Research Assistance Program (IRAP), raising the subsidy rate to almost 60 per cent on average for these firms.

In Lester (2012), I found that the large-firm, or regular, tax credit generated a net benefit for Canadians but that the small-firm, or enhanced, credit harmed rather than helped economic performance. Information on spillovers by size of firm was not available in 2012, so I used the same spillover rate, 56 per cent, for both firm-size categories. Myeongwan Kim and I (2019) have recently developed estimates of spillover benefits by size of firm. Our research shows that the firms eligible for the 35 per cent credit generate much smaller spillover benefits — approximately 20 per cent — than the larger firms claiming the 15 per cent credit, which generate spillovers of just over 50 per cent. The average spillover rate across all firms is 33 per cent.

In this report, I provide updated estimates of the net social benefit of the federal regular and enhanced SR&ED investment tax credits as well as estimates of the optimal rates for these credits. I also extend the analysis to provincial R&D subsidies in Alberta, which were eliminated effective 2020, and in Ontario and Quebec, which are the only provinces that subsidize R&D performed by small and large firms at different rates.

The analysis continues to find that the federal large-firm credit generates a net benefit for Canadians and that the federal small-firm credit fails a benefit-cost test. The regular credit rate is below its optimal value, so increases in the subsidy rate from provincial programs result in a larger net social benefit. As a result, Alberta would obtain a net benefit by reinstating a subsidy for R&D performed by large firms. The federal enhanced credit performs poorly because of relatively small spillovers and high costs associated with applying for the credit. The federal small-firm subsidy rate is well above its optimal level, so provincial programs increase the social cost of subsidizing R&D performed by small firms, indicating that multilateral action to reduce provincial subsidies would improve economic performance. Further, analyses of the Quebec and Ontario small-firm subsidy programs indicate that unilateral reduction or elimination of these subsidies would be sound public policy.

The general policy recommendation flowing from my analysis is that subsidies for R&D performed by small firms should be reduced and subsidies for large firms should be raised. The optimal statutory subsidy rates obtained from the benefit-cost analysis are 28 per cent for large firms and 11 per cent for small firms. However, the net social benefit only declines by about 10 per cent as the large-firm credit ranges from 19.5 per cent to 36 per cent, or as the enhanced credit rate rises from 10 to 19.5 per cent. As a result, there would be a substantial income gain if the federal government increased its large-firm credit rate to 20 per cent and reduced its small-firm subsidy rate to 10 per cent. The income gain would be further increased if provincial governments adopted a 10 percent subsidy rate for all firms. With this change, the combined federal-provincial statutory rate would be 28 per cent for large firms and 19 per cent for small firms. Thousands of small firms would continue to top up the generally available subsidies with grants from IRAP, which could raise the subsidy rate to about 40 per cent for these particularly promising firms.

FEDERAL AND PROVINCIAL R&D INVESTMENT TAX CREDITS

The federal government provides a tax credit equal to 15 per cent of current expenditures on R&D by large firms and 35 per cent for expenditures by Canadian-controlled small and medium-sized private corporations.[2] For convenience, these two categories are labelled large and small firms. The federal SR&ED investment tax credit is refundable for smaller firms, making it equivalent to a direct subsidy, but must be used to reduce tax otherwise payable for large firms. Smaller firms can apply for the 35 per cent subsidy on up to $3 million in R&D investment. Prior to 2019, the $3 million expenditure limit was reduced to zero as prior-year taxable income rose from $500,000 to $800,000 and as capital assets rose from $10 million to $50 million. Starting in 2019, only the capital asset phase-out applies.

The effective subsidies on R&D rates are lower than the statutory rates because not all spending on R&D is included in the base for the credit: capital expenditures are excluded and only 80 per cent of eligible R&D that is outsourced is included. These adjustments reduce the effective subsidy rate for small firms to 32.1 per cent and to 13.7 per cent for large firms. (Table 1).

[2] Smaller firms that are controlled by non-Canadians or listed on stock exchanges receive the regular credit.

TABLE 1: FEDERAL STATUTORY AND EFFECTIVE SR&ED INVESTMENT TAX CREDIT RATES (IN %)

	Small Firms[1]	**Large firms**
Statutory rate	35.0	15.0
Exclude all capital from eligible expenditures[2]	-2.2	-0.9
Exclude 20% of R&D outsourced in Canada[3]	-0.7	-0.3
Effective subsidy rate	32.1	13.7
Reduced value of tax depreciation allowances	-2.9	-2.1
Reduced value of delayed claims[4]	n.a.	-1.8
Effective revenue rate[5]	29.2	9.9

Sources: Expert Review Panel on Research and Development (2011b); Statistics Canada tables 27-10-0333-01 and 27-10-0346-01; author's calculations.

1. Canadian-controlled private corporations
2. The capital share in R&D spending was 6.3% on average from 2014 to 2017.
3. Only 80% of R&D prepared under contract is eligible for the tax credit. On average from 2014 to 2017, 10.3% of R&D owned by Canadian firms was outsourced to other firms in Canada.
4. The large firm credit is not always claimed as it it earned. From 2000 to 2007 delays reduced the present value of claims by 15%.
5. Tax revenue forgone per dollar of R&D spending (accrued present value basis).

I make two additional adjustments to determine the amount of tax revenue forgone per dollar of R&D spending. First, the effective subsidy rate is reduced to account for the reduced value of tax depreciation allowances, which are based on the amount spent on R&D net of investment tax credits. The smaller deduction reduces the credit by the corporate income tax rate. This approach prevents firms from claiming all spending on R&D as a deductible expense when their cost has been reduced by the credit.[3] Second, the large-firm credit is not always claimed as it is earned. The delay in making claims reduces the present value of the tax revenue forgone by about 15 per cent.[4]

3 When the base for tax depreciation allowances is reduced by the amount of the credit, it is often described as a "taxable" credit. A non-taxable credit raises the effective subsidy rate for a given subsidy since it allows a deduction for an expense that has not been incurred.

4 While the impact of delayed claims on the amount of tax revenue forgone is clear, the impact on the incentive to invest is more difficult to determine. Most firms undertake R&D with the expectation that the credits will be used as earned, but changes in the economic environment such as a cyclical downturn or an intensification of competition that reduces profits may prevent them from doing so. In contrast, not all startups claiming the large-firm credit would expect to use the credit as it is earned. In addition, based on previous experience with claiming credits, some firms may anticipate that they will not be used as earned. In both cases, firms would calculate the expected present value of the credits when assessing how to respond to the incentive. There is no information available on the reasons why claims are delayed. I implicitly assume that all firms claim the credit with the expectation that it will be used approximately as earned by making no adjustment to the effective subsidy rate for delayed claims.

TABLE 2: FEDERAL AND PROVINCIAL STATUTORY SR&ED INVESTMENT TAX CREDIT RATES

	Provincial Tax Credit Rate	Federal Plus Provincial Rates[1]	
		Small Firms[2]	Large Firms
Alberta, Northwest Territories and Prince Edward Island	0%	35.0%	15.0%
Ontario (small/all firms)[3]	8% / 3.5%	40.2%	18.0%
British Columbia and Saskatchewan	10%	41.5%	23.5%
Manitoba	15%	44.8%	27.8%
Nova Scotia, New Brunswick, Newfoundland and Labrador and Yukon	15%	44.8%	27.8%
Quebec (small/large firms)[4]	19.2% / 9.0%	47.8%	22.8%
Provincial weighted average			
Small firms	10.9%		
Large firms	6.0%		
Federal-Provincial combined		42.1%	20.1%

1. The statutory federal credit is 35% for small and medium-sized Canadian-controlled private corporations (CCPCs) and 15% for other firms. The base for the federal credit excludes provincial credits.
2. Canadian controlled private corporations spending less than $3 million on R&D and having less than $10 million in assets.
3. The small firm subsidy is in addition to the non-refundable all-firm credit.
4. The Québec statutory credit rates of 30% for small firms and 14% for large firms apply to wages and salaries for R&D performed in house plus 50 percent of contracts. The rates shown in the table have been adjusted for the narrower provincial base.

All provincial governments except Alberta[5] and Prince Edward Island subsidize R&D performed within their borders. Provincial credits are refundable for all firms in the Atlantic Provinces, Quebec and Manitoba. Ontario, Saskatchewan and B.C. offer refundability for small firms only. Most provinces use the base and the expenditure limit defined by the federal government. The key exception is Quebec, where the base is labour costs and 50 per cent of outsourced R&D. The statutory credit rates of 14 per cent and nine per cent on labour cost result in a rate of about nine per cent for large firms and 19 per cent for smaller Canadian-controlled firms.[6] Statutory provincial tax credit rates, where provided, range from 3.5 per cent to 15 per cent for large firms and from eight per cent to 19 per cent for small firms. Only Quebec and Ontario provide different rates for small and large firms. The combined federal-provincial statutory rate is 42 per cent for smaller firms and 20 per cent for large firms (Table 2). Adjusted for base exclusions, the combined federal-provincial effective credit rates are 38.9 per cent and 18.5 per cent for small and large firms, respectively (Table 3).

5. Alberta eliminated its R&D subsidy in 2020. A new grant targeted at small and medium-sized firms is expected to be available as of January 2021. The grant will be in two parts: an eight per cent payment on the level of R&D spending and a 12 per cent payment on spending above a base level, tentatively set at the average level of spending over the previous two years. The grant will provide benefits on up to $4 million in R&D spending. In the absence of the cap, the grant would be equivalent to a refundable tax credit.

6. These estimates are based on expenditure shares for all firms performing R&D in Canada. The shares likely differ by size of firm and by province.

TABLE 3: FEDERAL AND PROVINCIAL EFFECTIVE[1] SR&ED INVESTMENT TAX CREDIT RATES (2020 IN PERCENTAGE)

	Federal	Provincial[2]	Combined[3]
Small firms[4]	32.1	10.0	38.9
Large firms	13.7	5.5	18.5
Small minus large	18.3	4.5	20.4

1. Effective subsidy rate. See Table 1.
2. Expenditure-weighted sum of provincial effective rates.
3. The base for the federal credit is reduced by the amount of provincial assistance provided.
4. Canadian-controlled private corporations, as defined in Table 2.

Tax assistance rates for R&D for large firms in Canada do not stand out relative to other countries, but support for small firms is relatively generous. Lester and Warda (2020) present estimates of R&D subsidy rates for members of the Organisation for Economic Co-operation and Development (OECD) and four key emerging and transition economies. These subsidy rates include all forms of tax support for R&D, not just tax credits.[7] Lester and Warda (2020) show that Canada's tax assistance for R&D performed by large firms ranks 16th out of the 34 countries in the comparison group. Lester and Warda (2018) report that Canada is one of eight countries that provide broad-based preferential treatment for R&D performed by small firms and is the third most generous in the comparison group of countries.

THE BENEFIT-COST ANALYTICAL FRAMEWORK[8]

The federal and provincial governments provide substantial subsidies to business. In a recent paper (Lester 2018a), I estimated that the federal government and the four largest provinces spent $30 billion on business subsidies in fiscal year 2014-15, split approximately evenly between the two levels of government. Most of the subsidy programs were implemented with the objective of improving economic performance: the expectation was that these economic development programs would raise the real income of Canadians. Benefit-cost analysis provides a framework for assessing if this objective is being achieved. It calculates the net benefit accruing to Canadian citizens after considering the social benefits and costs of policy initiatives.

A fundamental point is that overriding the private market result with a subsidy can only provide a net benefit to Canadians if the market is failing to allocate labour and capital to their most efficient uses. There is well-recognized market failure in the performance of R&D. When firms perform R&D, they create knowledge that allows them to introduce

7 For example, most countries provide a tax benefit to firms by allowing the immediate deduction of current expenses incurred when performing R&D. Immediate deductibility amounts to a subsidy because the knowledge created by the expenditure is expected to generate revenues over time, in which case the standard procedure is to deduct the corresponding expenses over time as well.

8 In this paper, I use a slightly modified version of the model set out in Lester (2012). In addition to a different approach to modelling the cost of financing a policy initiative, transfers to non-Canadians through profit outflows and terms of trade effects are included in the base case analysis rather than as alternative scenarios. The earlier paper includes a detailed discussion of the model as well as alternative modelling approaches.

new products, improve existing goods and services or reduce production costs. However, some of the knowledge created inevitably leaks out or spills over to other firms, which allows them to benefit as if they had performed the R&D themselves. On the other hand, when firms bring new products to market and develop new production processes, the increase in sales can be at the expense of other firms, which reduces the spillover benefit of investment in R&D. Empirical work by Bloom, Schankerman and Van Reenen (2013) and Lucking, Bloom and Van Reenen (2017) indicates that the positive impact of knowledge spillovers is greater than the negative product market rivalry or business-stealing effect. The net spillover benefits improve Canada's overall economic performance, but firms do not consider them when deciding how much to invest in R&D, so intervention to encourage more R&D is the right policy response.

While the additional R&D induced by a subsidy results in a social benefit, resources are assumed to be fully employed so this output gain is nullified by losses in other sectors when taxes are increased or spending is cut to finance the subsidy. Further, overriding the market allocation of labour and capital with a subsidy makes the production of R&D less efficient. This reduction occurs because, by reducing the hurdle rate for a profitable investment, a subsidy encourages investment in R&D that provides a net-of-subsidy return that is less than it would be in the absence of the subsidy.[9]

How the R&D investment tax credit is financed affects its net benefit. This can be seen most easily by considering the case where the subsidy is tax-financed. Taxes unavoidably harm economic performance by affecting incentives to work, save and invest. The impact on incentives varies by type of tax. Value-added taxes, such as the GST, are much less harmful than corporate income taxes, which are a tax on business investment.[10] As a result, if the investment tax credit, which reduces the tax burden on investment, is financed by an increase in the GST the overall economic cost of taxation will decline and the net benefit from subsidizing R&D will rise. The economic cost of taxation will also decline if the R&D investment tax credit is financed by an increase in the corporate income tax rate. An investment tax credit applies to new investment only while the corporate income tax applies to the net income arising from the existing capital stock as well as new investment. Since only part of the tax revenue forgone from a tax rate reduction stimulates additional investment, the efficiency cost per dollar of tax revenue forgone is higher for the corporate income tax rate than for an investment tax credit.[11]

Financing the R&D subsidy by spending reductions also affects the net benefit but assessing the cost of lower spending is more complicated because of the number of programs that could be considered. A simplifying assumption that could be made is

---

9 In the benefit-cost analysis, this efficiency loss is measured as the change in producer surplus calculated using a simple version of the Harberger triangle methodology.

10 See Baylor and Beauséjour (2004) and Ferede and Dahlby (2016) for empirical estimates of the marginal social cost of taxation by major revenue source.

11 The difference is substantial. Baylor and Beauséjour (2004) report that the marginal social benefit per dollar in tax revenue forgone from a corporate income tax rate reduction is 37 cents compared to 135 cents for an investment tax credit.

that government spending is increased until the marginal benefit of spending equals the marginal cost of raising taxes. With this assumption, financing the R&D investment tax credit with spending cuts is equivalent to financing it with a share-weighted increase in the major taxes, which would reduce the efficiency cost of taxation and increase the net benefit of subsidizing R&D. It is also possible to assume that the R&D subsidy would be financed by eliminating some particularly wasteful spending program(s), which would provide a "double dividend" if the spending program were harming rather than helping economic performance.

However, as discussed in an earlier paper (Lester 2018b), including the benefits from an improved tax structure or higher quality spending overstates the net benefit from subsidizing R&D. To illustrate the point, consider a targeted investment tax credit that does not address an externality and that is financed by an increase in the corporate income tax rate. The investment tax credit would reduce efficiency by interfering with the market allocation of resources, but the change in the structure of taxation would improve efficiency by reducing the economic cost of taxation. The policy could therefore pass a benefit-cost test despite causing a misallocation of resources.

To avoid this outcome, the benefit-cost analysis does not include the net benefit arising from changes to the structure of taxation or the quality of spending. Such changes could be made without subsidizing R&D, so it is more appropriate to assess their merits independently.

Subsidizing R&D imposes several other costs. The most obvious costs are those incurred by governments to administer the subsidy and by private firms to apply for the subsidy and to comply with its terms and conditions. A more subtle issue is the implicit transfer of the subsidy to non-Canadians. If the subsidy is paid for by one group of Canadians and received by another, there is no direct impact on Canadians' income. However, if foreigners receive some of the subsidy, Canadians suffer a direct income loss. One way this transfer could occur is through subsidy-induced increases in profits of foreign-owned firms. Firms increase R&D in response to a subsidy because it reduces the hurdle rate for a profitable investment. As a result, part of the subsidy is transferred to the firms performing the R&D, some of which are foreign-owned. A second way this transfer could occur is through subsidy-induced reductions in the price of exported goods. Some of the subsidy will be passed through to the prices of the goods and services developed with the subsidized R&D. Since the commercialized R&D will be sold on domestic and world markets, some of the subsidy will be transferred to foreigners.

The government can in principle choose a subsidy rate that maximizes the net benefit or minimizes the loss. This possibility arises if, as seems likely, the spillover benefit is a constant share of the additional R&D induced by the subsidy and the costs rise with the subsidy rate. Regression-based estimates of spillovers implicitly assume that the spillover rate is constant over the sample period, although some analysts test the assumption by performing regressions over sub-periods in the sample. For example, Lucking, Bloom and Van Reenen (2017) assess the stability of the spillover rate over the 30 years ending in 2015. They conclude the spillover rate has been "broadly stable" over this period. On the other hand, the required private rate of return falls as the subsidy rate rises, so the efficiency cost of overriding market signals becomes a larger share of the additional R&D induced by the subsidy as it rises.

In these circumstances, the net benefit will have an inverted "U" shape: it initially rises along with the subsidy rate but eventually declines as the private marginal return on R&D continues to fall. In the absence of other costs, the net benefit would be maximized by setting the subsidy rate equal to the spillover rate.[12] However, administration and compliance costs as well as transfer of the subsidy to non-Canadians reduce the net benefit and the optimal subsidy rate. Although governments can in principle set the subsidy rate at a level that maximizes the net benefit, the optimal subsidy rate cannot be precisely determined. Further, the net benefit may not change substantially as the subsidy rate varies around the estimated optimal rate.

If a subsidy is successful in raising income, taxes can be reduced, which would improve economic performance by lowering harmful effects of taxes on incentives to work, save and invest.

I perform the benefit-cost framework in what is known as a partial equilibrium framework: benefits and costs are calculated without any feedback effects from the economy. The alternative is to embed the benefit-cost analysis in a complete model of the economy. The partial equilibrium framework is appropriate because the induced effects on the economy are not strong enough to have a substantial impact on the benefit-cost results.[13] For example, the partial equilibrium approach does not capture the increase in real income arising from terms of trade effects. R&D subsidies result in lower prices for R&D-intensive products, which increases demand by domestic and foreign consumers. The increased demand improves the trade balance, which puts upward pressure on the exchange rate. The resulting improvement in the terms of trade raises the real income of Canadians. However, while the subsidy has a substantial impact on the amount of R&D performed in Canada, the impact on overall exports is small. An illustrative calculation suggests that overall exports are about .5 per cent higher because of the subsidy, which is not large enough to have a substantial impact on the terms of trade.[14]

Although not all the benefits and costs are explicitly adjusted for differences in timing, the net benefit can be interpreted as an annual accrued amount in response to an

---

12 This is the point at which the marginal benefit of the subsidy equals its marginal cost.

13 I am aware of nine benefit-cost analyses of R&D investment tax credits prepared by other authors since the early 1990s: Australian Bureau of Industry Economics (1993), Australia Industry Commission (1995), Finance Canada and Revenue Canada (1997), Lattimore (1997), Cornet, Maarten (2001), Moon and Yoon (2004), Russo (2004), Dahlby (2005) and Parsons and Phillips (2007). Three of the studies use a general equilibrium model: the Australian Industry Commission, Finance/Revenue Canada and Russo.

14 The subsidy-induced change in exports was calculated as follows. The weighted average subsidy rate is estimated at 18.3 per cent, which results in a 23 per cent increase in the amount of R&D performed. Empirical work by Kim and Lester (2019) finds that a one per cent increase in R&D increases overall output of R&D performers by .04 per cent. The 23 per cent increase in R&D would therefore raise output by .9 per cent. Sales of firms that performed or paid for R&D are estimated at $812.7 billion in 2017, so the subsidy accounted for about $7.5 billion in sales. Exports represent about 45 per cent of sales, so the subsidy-induced rise in exports could have been as much as $3.5 billion, which was about .5 per cent of the $664.9 billion in exports in 2017.

annual subsidy. Administration expenses, compliance costs and resource misallocation costs occur annually in response to the subsidy. Although knowledge spillovers occur over time, with certain assumptions, the spillover rate, which is the rate of return on the spillover pool, can be interpreted as an annual rate of return on R&D.[15]

Current spending on R&D also gives rise over time to products and services that are sold by the firms performing the R&D. In this case, however, the delay in commercializing R&D has to be explicitly recognized. Based on a U.S. survey by the National Science Foundation and other agencies,[16] I assume that the average lag between performing R&D and realizing revenue from the investment is two years. I apply a three-year lag to the generation of profits.

The R&D tax credit is evaluated assuming that knowledge spillovers and business-stealing effects are the only relevant market failures in the economy. However, as discussed in an earlier paper (Lester 2017), it seems likely that the development of small firms is impeded by several other factors, including capital market failures, more burdensome costs of filing tax returns and applying for R&D support programs, barriers to entry erected by larger firms and tax policies that unintentionally hinder entrepreneurs. While the best policy approach would be to correct these market failures with a separate policy measure, R&D subsidies could be a second-best solution.

In some cases, however, R&D subsidies for all small firms may be too blunt an instrument. For example, a failure[17] in the risk-capital market is sometimes adduced to justify setting the subsidy rate for small firms higher than would be warranted if the spillover benefit is considered in isolation.[18] The nature of the market failure suggests a nuanced approach would be more appropriate. Boadway and Keen (2006) find that the risk-capital market failure is more likely to cause over-investment than under-investment if both outside investors and entrepreneurs are risk-neutral. Allowing for risk-averse entrepreneurs, Braido, da Costa and Dahlby (2011) demonstrate that under-investment is the more probable outcome. Risk aversion is likely to be pronounced in the “seed” or “angel” capital segment of the risk-capital market, which is much smaller than the “venture capital” segment. R&D subsidies therefore may be too blunt an instrument to be considered a second-best policy to address a capital market failure.

---

15 See Hall, Mairesse and Mohnen (2010, 6) for a discussion. If the marginal product of R&D and the discount rate are constant, and the planning horizon is infinite, direct estimation of the rate of return results in a coefficient that can be interpreted as the internal rate of return on the spillover pool. The internal rate of return equates a dollar of investment in R&D to the present value of the marginal productivities of that investment in the future.

16 Quoted in Li and Hall (2016). The survey covered 6,381 firms in 38 industries. The average gestation lag is 1.94 years, and the lag is longer than three years for only 1.35 per cent of firms.

17 The market failure is adverse selection arising from asymmetric information available to investors and entrepreneurs.

18 See, for example, Brander, Egan and Hellmann (2010).

KEY ASSUMPTIONS UNDERLYING THE NET BENEFIT ESTIMATES

Using the benefit-cost framework to assess the federal credits requires estimates of the spillover rate, the responsiveness of R&D to subsidy-induced reductions in its cost, the proportion of the subsidy that is transferred to foreigners through lower export prices and through profits of foreign-owned firms operating in Canada, and the costs incurred by governments to administer the incentive and incurred by firms to comply with program requirements. Table 4 presents the values of these parameters used in the benefit-cost analysis along with some brief notes on sources and methods. Additional detail is provided in Annex A.

TABLE 4: KEY INDICATORS IN THE BENEFIT COST ANALYSIS (PERCENTAGE, EXCEPT AS NOTED)

	Small Firms	Large Firms	Notes on sources and methods
Federal effective subsidy rate[1]	32.1	13.7	See Table 1.
Spillover rate[2]	19	52	Kim-Lester (2019).
Price responsiveness of R&D[3]	-1.4	-1.0	Median value of 35 estimates for large firms and eight estimates for small firms.
Percentage of subsidy transferred to foreigners through lower export prices	2.1	18.0	Based on a commercialization rate for large (small) firms of 73% (65%), a gestation lag of 2 years, an export intensity of 63% (10%) and a 42% pass-through of the subsidy to prices. The pass through percentage was developed assuming imperfect competition.
Percentage of subsidy absorbed in profits of foreign MNEs	0.0	3.0	Based on a 46% share of Canadian R&D performed by foreign MNEs and a 15% pre-tax rate of return on R&D. Foreign firms are not eligible for the small firm credit.
Administration expenses[4]	2.7	1.7	Total administration expenses represented 2.2% of claims in 2018-19. This cost was allocated to large and small firms based on the number and value of claims.
Compliance costs[4]	14.2	4.7	Based on survey results reported in Lester (2012).

1. Percentage reduction the cost of business R&D performed in Canada.
2. Reduction in production costs per $100 of R&D induced by the subsidy.
3. Elasticity, which is the percentage change in R&D spending induced by a one percentage point decline in the cost of performing R&D.
4. Percentage of the subsidy provided.

RESULTS

THE FEDERAL LARGE-FIRM CREDIT

The federal large-firm, or regular, SR&ED investment tax credit generates a net benefit to Canadians of about $350 million, using the base case parameters (Table 5). The net benefit represents almost 26 per cent of the tax revenue forgone. The key benefit is the reduction in production costs arising from knowledge spillovers. On the cost side, the largest element is a transfer of the subsidy to foreigners through lower export prices of R&D-intensive products. Transfers through profits of foreign-controlled firms are much smaller but taken together, transfers of the subsidy to non-Canadians amount to just over a third of the spillover benefits. In contrast, the lower private return on R&D induced by the subsidy accounts for only 13 per cent of the spillover benefit. Since there is a net benefit, real income and hence tax revenue (net of administration expenses) are higher, which provides the federal government with the opportunity to reduce taxes or increase spending. Both options are welfare enhancing, although the efficiency gain from lower tax rates represents less than three per cent of the spillover benefit.

TABLE 5: BENEFIT-COST ANALYSIS OF THE FEDERAL LARGE FIRM SR&ED INVESTMENT TAX CREDIT (MILLIONS OF $, EXCEPT AS NOTED)

R&D Spending by large firms[1]	13,510
Effective Subsidy Rate[2]	13.7%
Tax revenue forgone[3]	1,337
Price elasticity of demand	-1.00
Subsidy-induced R&D	1,605
Spillover rate (% of induced R&D)	52%
Benefits	
Lower production costs from spillovers	835
Costs	
Lower private return on R&D	-108
Transfer of the subsidy to non-Canadians	
Profits of foreign-controlled firms	-48
Lower export prices of commercialized R&D	-236
Administration and compliance costs	-118
Total costs	-511
Benefits less costs	324
Potential efficiency gain from tax rate reduction	22
Net Benefit	346
Percentage of tax revenue forgone	25.9

1. R&D investment intentions for 2018 multiplied by the estimated share of large firm R&D performers.
2. See Table 1.
3. This is an estimate of the accrued present value of the reduction in tax liabilities. It includes adjustments for the lower value of tax depreciation allowances and for delays in claiming the credit.

The estimated value of the net social benefit is sensitive to assumptions about the responsiveness of real spending on R&D to the subsidy (i.e., the price elasticity of R&D), the determinants of how much of the subsidy is transferred abroad and the spillover rate. The empirical estimates of the price elasticity of R&D are relatively tightly clustered around -1 but the distribution is not symmetric: half of the estimates are between -0.90 and -1.25.[19] Holding all other parameters constant, the net social benefit falls roughly a fifth when the elasticity is reduced to the 25th percentile and rises almost 50 per cent when the elasticity is increased to the 75th percentile of the estimates (Table 6, column 3).

The results are also sensitive to the percentage of the subsidy that is passed through to prices, which is an important determinant of how much of the subsidy is transferred to

19 These estimates have been adjusted to be representative of large firms.

foreigners. The pass-through percentage varies with the demand and supply elasticities as well as the competitive environment in the market for R&D-intensive products. Although the demand and supply elasticities are empirically based, there are not enough estimates to use their distribution to establish an illustrative confidence interval as was done for the R&D demand elasticity. As an alternative, I assess the impact of raising and lowering the elasticities by 50 per cent from their base case values. The indicator of competition in the market for R&D-intensive products was arbitrarily set at .5, which is midway between the indicator for perfect competition and monopoly. In the sensitivity analysis, I vary this parameter by 50 per cent from its base case value.

To keep the number of alternatives manageable, I examine the impact of combinations of elasticities and competitive indicators that give a plausible range for the pass-through percentage. The pass-through percentage is at what I consider the low end of the plausible range — 23 per cent — when the demand elasticity is -6, the supply elasticity is two and the competition indicator is set at .75. With this pass-through rate and when the demand elasticity is assumed to be -1.25, the net benefit rises from its base case value by just over 80 per cent to $628 million (Table 6, column 2). The pass-through rate is at the high end of the plausible rate — 65 per cent — when the demand elasticity is set at -2, the supply elasticity at 6 and the competition indicator is set at .25. With these assumptions and if the R&D demand elasticity is assumed to be -.9, the net benefit falls by almost 60 per cent from its base case value to $140 million.

TABLE 6: NET BENEFIT FROM THE LARGE FIRM SR&ED INVESTMENT TAX CREDIT -- SENSITIVITY TESTS (MILLIONS OF DOLLARS)

	Price pass-through percentage		
R&D Price Elasticity	23	42	65
-0.90	392	277	140
-1.00	461	**345**	210
-1.25	628	513	376

The key message from the simulations presented in Table 6 is that if the base case spillover rate is accepted as accurate, it is highly likely that the large-firm subsidy is generating a positive net benefit. Since the Kim-Lester estimate is unique, I perform sensitivity tests based on the confidence interval for the estimated coefficient. Chart 1 shows the net benefit for combinations of the spillover rate and the demand price elasticity that result in a zero net benefit with all other parameters at their base case values. Combinations above and below the line result in a positive and negative net benefit, respectively. The dashed line shows combinations giving a zero net benefit with the percentage pass-through of the subsidy set at the top end of its plausible range, which reduces the net benefit for a given value of the price elasticity. The box in Chart 1 includes the 90 per cent confidence interval for the spillover rate (41 to 63 per cent) and half of the price elasticity estimates in the literature survey.

The net benefit remains positive when I vary the spillover rate over its 90 per cent confidence interval while keeping the price elasticity at -1. The net benefit remains positive for all combinations contained in the box in Chart 1 even when the price pass-through percentage is increased to the top end of its plausible range. These results suggest that it is highly likely that the large-firm subsidy is generating a positive net benefit. However, subsequent empirical work may provide a different perspective on the large-firm spillover rate. The spillover rate would still generate a net benefit if it fell to 32 per cent while keeping other parameters at their base case values. If the price elasticity is assumed to be -1.5, which is on the 83rd percentile of the distribution of estimates, a spillover rate as low as 25 per cent would allow the large-firm subsidy to generate a net benefit.

Further, it is worth keeping in mind that estimates of the R&D price elasticity could be overstated because of a relabelling effect. Based on the results reported by Guceri (2018) and Guceri and Liu (2019), estimated elasticities could be overstated by about a quarter, which would put the median elasticity at about -.75. This reduces the net benefit to $35 million if the price pass-through percentage is 65 per cent and the spillover rate is 52 per cent. At the adjusted low end of the elasticity range, -.67, the net benefit is negative with the same assumptions for the pass-through percentage and the spillover rate.

CHART 1: NET BENEFIT OF THE LARGE FIRM SR&ED INVESTMENT TAX CREDIT SENSITIVITY ANALYSIS

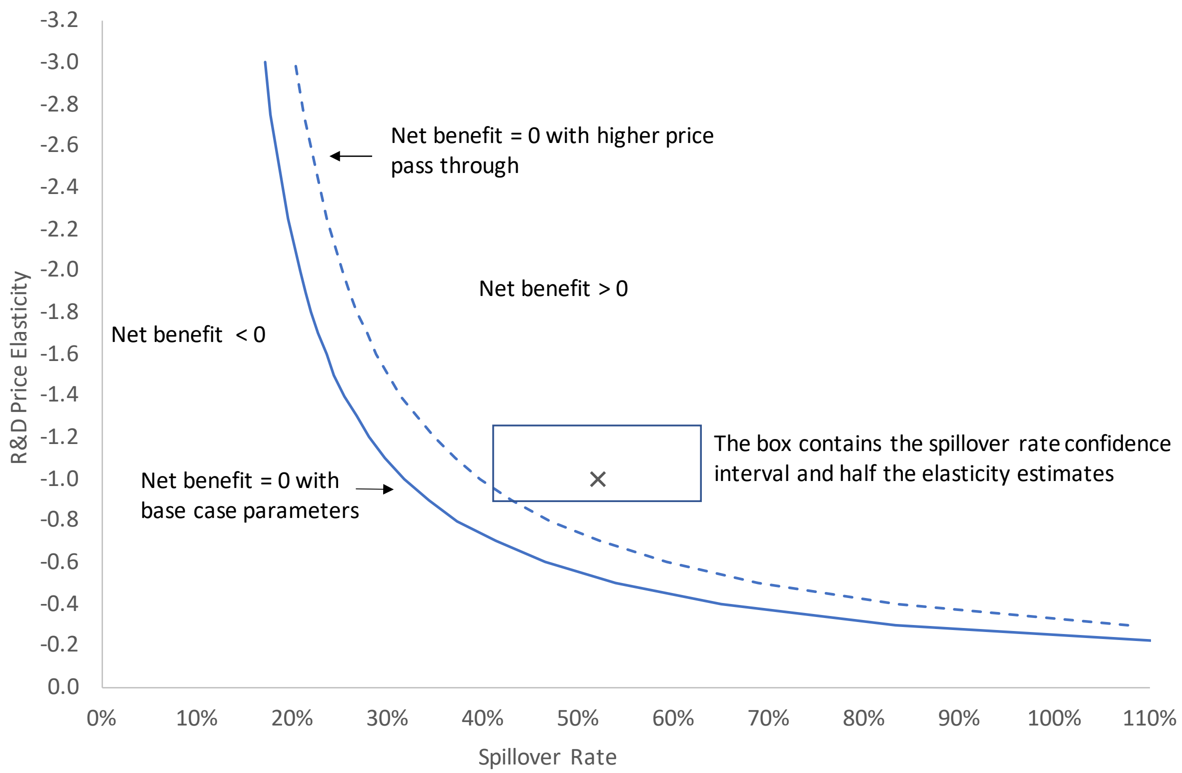
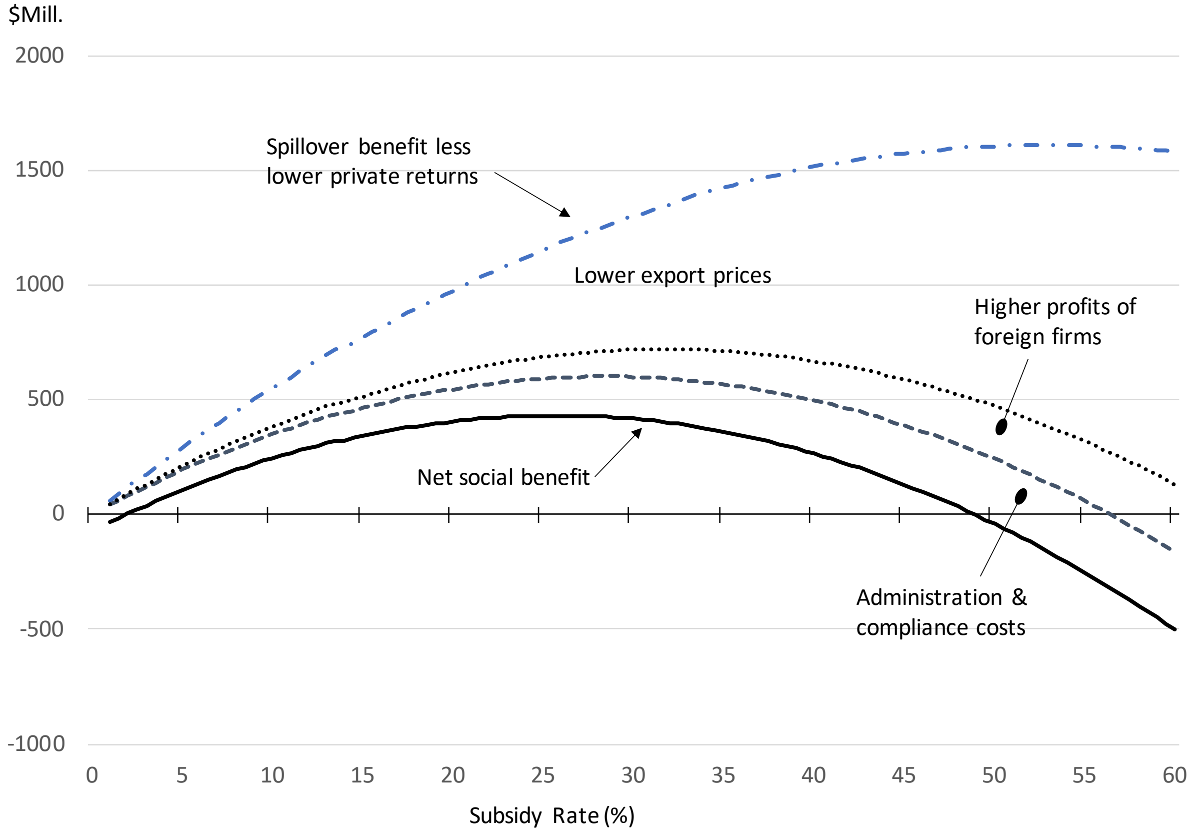


Chart 2 shows how the net benefit changes with the effective subsidy rate as well as how various elements contribute to the net benefit.[20] The top line in the chart shows the spillover benefit less the impact of lower private returns. It highlights the observation made earlier that if spillovers are a constant or falling share of the R&D induced by the subsidy, the cost of falling private returns to R&D becomes a larger share of the spillover benefit as the subsidy rate rises. If the spillover benefit and falling private returns were the only elements of the benefit-cost calculation, the net social benefit would be maximized by setting the subsidy rate equal to the spillover rate, which is 52 per cent. However, transfers of the subsidy to non-Canadians also rise relative to the spillover benefit as the subsidy rate increases; this cuts the optimal effective subsidy rate to 28 per cent. Fixed administration and compliance costs rise slowly with the subsidy rate as more firms apply for the credit, but variable costs, which are determined by the value of claims also rise with the subsidy rate. This reduces the optimal subsidy rate to 25.5 per cent. The net benefit changes slowly near the optimal rate, declining less than 10 per cent as the subsidy rate falls to 18 per cent and rises to 33 per cent.

CHART 2: DECOMPOSITION OF THE NET SOCIAL BENEFIT OF THE LARGE FIRM SR&ED CREDIT



---

20 Note that firms do not participate in the program until the credit rate exceeds the average cost of compliance, which is .6 cents per dollar of investment.

PROVINCIAL LARGE-FIRM SUBSIDIES

The federal large-firm effective subsidy rate is about 12 percentage points below the estimated optimal rate. However, as discussed earlier, provincial governments also subsidize R&D. The weighted average provincial effective subsidy rate is 5.5 per cent, which results in a federal-provincial subsidy rate of 18.5 per cent after adjusting for the exclusion of provincial subsidies from spending eligible for the federal tax credit. On average then, provincial subsidies for R&D performed by large firms are generating a net benefit and an increase in the combined rate would raise real income. In particular, raising the provincial statutory credit rate in Ontario to 10 per cent (just above the unweighted provincial average) and restoring the 10 per cent Alberta subsidy[21] would raise real income in those provinces. In addition, by reducing the variation in provincial subsidy rates, R&D would be distributed more efficiently across the country.

Unilateral provincial initiatives have different impacts than a national program because of the greater openness of provincial economies — higher mobility of capital and labour within Canada along with greater export and import intensities — and industrial specialization. If a province increases the subsidy rate unilaterally, the response of R&D to the subsidy will be stronger than for a national program. Firms performing R&D in the initiating province will increase their spending and if they are operating in more than one province, they will shift R&D labs across provincial boundaries. Greater openness also means that a larger share of R&D will be commercialized outside of a given province and when commercialized in that province, a greater share will be sold beyond its boundaries, both of which will reduce the benefit by transferring more of the subsidy to non-residents.

Differences in industrial structure could affect the spillover rate across provinces. Kim and Lester (2019) report that spillovers are above average in manufacturing and three service-producing industries,[22] but not statistically different from zero in other industries. More than half of Alberta's R&D was performed in the oil and gas sector in 2014, compared to eight per cent nationally (Table 7), so it is possible that the spillover rate is smaller than the national average in Alberta. However, the evidence Kim and Lester present is not conclusive since they compare spillovers in four key industries to spillovers in all other industries — there is no information available on the spillover rate in the oil and gas sector. Consequently, in the base case analysis of Alberta R&D subsidies, I assume the spillover rate is equal to the national average, but I do undertake some sensitivity analysis of changes in the spillover rate.

---

21 The Alberta subsidy was a 10 per cent refundable tax credit capped at $400,000. Without the cap, the credit rate on eligible spending would be approximately nine per cent. The cap reduced the effective credit rate to 5.6 per cent on average in 2016 and 2017.

22 The service-producing industries are information and cultural industries; professional, scientific and technical services; and wholesale trade, although firms in the pharmaceutical and computer and communications equipment and supplies industries perform most of the R&D in wholesale trade. Firms in the four key industries account for about 90 per cent of the R&D performed in Canada.

TABLE 7: DISTRIBUTION OF R&D SPENDING BY INDUSTRY IN 2014 (%)

	Other goods-producing	Mining	Manufacturing	Services	ICT[1]	R&D Intensity[2]
Canada	3.1	8.0	33.5	55.4	30.5	1.0
Québec	1.2	n.a.[3]	53.4	43.7	20.5	1.5
Ontario	1.6	n.a.[3]	29.6	65.2	42.2	1.2
Alberta	1.0	53.7	10.8	34.4	12.9	0.6

1. Information and communications technology. It is included in manufacturing and services industries.
2. R&D spending divided by national or provincial GDP.
3. Included in other goods-producing industries.

The exclusion of provincial subsidies from the federal base reduces the cost-effectiveness of provincial programs in stimulating R&D. If a provincial government provides a subsidy at a cost of $100 million, firms only receive $86.3 million because the base for the federal credit (13.7 per cent) is reduced by $100 million. Provincial programs also result in additional administration and compliance costs. The additional compliance costs are likely to be small because of the similarities between the provincial and federal programs. The additional administration costs will also be small if the federal government administers provincial R&D subsidy programs, as occurs in all provinces except Alberta and Quebec. However, Alberta administrators accepted claims only if they were eligible for the federal program, but the government did incur costs to verify the amount of spending that took place in Alberta. In response to an Access to Information request, the Treasury Board and Finance Ministry of Alberta reported that these administration expenses were "generally less than 1 percent of the program cost." As noted in Table 4, the cost of administering the federal large-firm investment tax credit is estimated at 1.7 per cent of the value of claims.

An analysis of the benefits and costs to Alberta residents of restoring the 10 per cent SR&ED subsidy (without a dollar cap) for large firms is summarized in Table 8. Subsidy rates in other provinces are kept constant. The provincial program is modelled explicitly as an add-on to the federal program to capture the non-linearities in the subsidy rate and to illustrate the relative cost-effectiveness of the two programs. To assess restoring the Alberta credit for large firms, I adjusted the national parameter values as follows:

- The price elasticity of demand for R&D was doubled from -1 to -2 to illustrate the mobility of R&D across provincial borders.
- The export intensity of R&D-intensive products was increased from 63 per cent to 100 per cent for R&D performed in the oil and gas sector (i.e., oil and gas exports) and to 75 per cent in other sectors. The weighted average export intensity is 86 per cent.
- The elasticity of demand for R&D-intensive products was increased from -4 to -50 for oil and gas, reflecting an assumption that changes in Alberta's supply of oil and gas have little impact on its price. The elasticity was kept at -4 for other products. The elasticity of supply for industry output was reduced from eight to .5 for oil and gas and doubled to eight for other sectors. These changes reduce the percentage pass-through of the subsidy to prices from 42 per cent to 15 per cent.

- The share of R&D performed by foreign-controlled firms was reduced from 46 per cent to 31 per cent.[23]
- Based on the information provided by the Alberta government, additional administration costs are assumed to be one cent per dollar of subsidy. Additional compliance costs are assumed to be 10 per cent of the costs associated with the federal program.

I also made some adjustments to national program parameters when assessing the impact of the federal program in Alberta. More specifically, I raised the export intensity and lowered the supply elasticity of R&D-intensive products to capture the concentration of R&D in the oil and gas sector in Alberta. These changes raise the export intensity from 63 per cent to 79 per cent and reduce the price pass-through percentage from 42 per cent to nine per cent. The lower share of R&D performed by foreign-controlled firms also applies to the federal program. These changes substantially reduce the percentage of the subsidy transferred to non-Canadians compared to the average for the national program.

In addition, when modelling federal and provincial programs at the same time, I reduce the base for the federal tax credit by the amount of the relevant provincial credit. As a result, the net benefit of the federal program in Alberta rises to almost 47 per cent of the cost of the subsidy, which is almost 50 per cent higher than the reported average percentage for the national program (Table 8). Without the adjustment for the deductibility of provincial programs, the ratio of the net benefit to tax revenue forgone falls to 34 per cent.

With these assumptions, implementing a 10 per cent refundable investment tax credit with no dollar cap for large firms performing R&D in Alberta results in a net benefit of $64 million, which is 56 per cent of the projected cost of the subsidy in 2020 (Table 8). The Alberta subsidy is more cost-effective than the federal program in Alberta. The fiscal costs of the two programs are similar despite the large gap in effective subsidy rates because the federal revenue rate is reduced to capture the impact of delays in using credits and deductibility of the Alberta credit. Higher spillover benefits and lower administration and compliance costs increase the cost-effectiveness of the Alberta program while a larger reduction in the private return to R&D lowers cost-effectiveness. The investment response to a unilateral initiative is particularly strong because it encourages firms to shift R&D interprovincially. However, since the subsidy is approximately equal to the national average rate, the efficiency cost of the interprovincial shifting of activity is small.

---

23 Statistics Canada Table 27-10-0341-01. Note that companies operating in multiple provinces allocate provincial taxes based on sales and employment by province.

TABLE 8: NET BENEFIT TO ALBERTA RESIDENTS FROM IMPLEMENTING A 10% SR&ED SUBSIDY FOR LARGE FIRMS ($ MILLIONS, EXCEPT AS NOTED)

	Federal Program in Alberta	Federal Plus Alberta Program	Alberta Program[1]
R&D Spending by large firms	1,365	1,365	1,365
Effective Subsidy Rate[2]	13.7%	21.6%	7.9%
Effective revenue rate[3]	8.8%	17.3%	8.4%
Fiscal cost of the subsidy	121	236	115
Price elasticity of demand	-1.0	-1.37	-2.00
Spillover rate (% of induced R&D)	52%	52%	52%
Subsidy-induced R&D	142	309	167
Benefits			
Spillover	74.0	160.6	86.6
Costs			
Lower private rate of return on R&D	-10.2	-25.7	-15.4
Transfer of the subsidy out of Alberta			
Increased profits of foreign-controlled firms	-3.2	-4.6	-1.4
Lower export prices of commercialized R&D	-5.8	-13.4	-7.7
Administration and compliance	-12.0	-13.8	-1.8
Total costs	-31.2	-57.5	-26.4
Benefits less costs	42.8	103.1	60.2
Potential efficiency gain from tax rate reduction	3.2	7.0	3.8
Net Benefit	46.1	110.0	64.0
Percentage of fiscal cost	38.2	46.7	55.6

1. 10% refundable subsidy without a dollar cap.
2. See Table 1. The exclusion of the Alberta subsidy from the base for the federal credit is captured in a lower Alberta subsidy rate.
3. Both rates include an adjustment for a reduced base for tax depreciation allowances. The federal rate includes adjustments for the impact of delayed claims and deductibility of the Alberta credit.

As discussed above, spillovers in Alberta could be lower than the national average given the high concentration of R&D in the oil and gas industry. To illustrate the point, I calculated an Alberta spillover rate assuming zero spillovers in oil and gas and national average spillovers in other sectors. This gives an Alberta spillover rate that ranges from 23 per cent to 27 per cent, with the higher value obtained when the national spillover rate is calculated for the four key industries identified by Kim and Lester (2019).[24] Assuming a 23 per cent spillover rate, the net benefit from an Alberta R&D incentive remains positive, but falls to about $13 million.

I undertook a benefit-cost analysis of increasing Ontario's large firm tax credit from 3.5 per cent to 10 per cent. The results are similar to those for restoring the Alberta subsidy: real income in Ontario rises by about $125 million, which is almost half of the additional tax revenue forgone. Enriching the Ontario subsidy would elicit a strong

24 Kim and Lester report that the estimated spillover elasticity is 15 per cent higher in the four key industries than the all-industry average, which implies a spillover rate of about 60 per cent in the four industries.

response of R&D spending, although likely less than for Alberta since the scope for shifting activity across provinces declines with the size of the receiving province.[25]

In contrast to Alberta, the spillover rate in Ontario could be higher than the national average. Although there is no evidence on spillovers by province, the higher R&D intensity (R&D spending relative to provincial output) in Ontario may result in a higher than average spillover rate. There is some evidence that spillovers decline with the physical distance between performers and potential beneficiaries, so the concentration of R&D in Ontario could result in a higher spillover rate. Further, the high share of R&D spending on information and communication technology could have a favourable impact on the spillover rate.

THE FEDERAL SMALL-FIRM CREDIT

In contrast to the federal large-firm tax credit, a benefit-cost analysis of the enhanced or small-firm SR&ED subsidy shows a net loss. Using the base case values for the spillover rate (19 per cent), the price elasticity of demand for R&D (-1.4) and the percentage of the subsidy transferred to foreigners (2.1 per cent), the net loss is $185 million, which is 18 per cent of the estimated fiscal cost of the subsidy (Table 9). Two factors stand out in contributing to the net loss. First, the spillover rate is low relative to the effective subsidy rate (32.1 per cent). As discussed above, in the absence of other benefits the optimal subsidy rate is capped at the spillover rate, so there is downward pressure on the net benefit from the high subsidy rate. Second, administration and compliance costs are high, amounting to almost 17 per cent of the amount claimed. On the other hand, only a small portion of the subsidy is transferred to non-residents through lower export prices and since only Canadian-controlled firms are eligible for the enhanced or small-firm subsidy, there is no transfer of subsidy-induced profits to non-Canadians.

[25] The Ontario R&D price elasticity is assumed to be -1.75 compared to -2 for Alberta.

TABLE 9: BENEFIT-COST ANALYSIS OF THE FEDERAL ENHANCED SR&ED INVESTMENT INCENTIVE ($ MILLIONS, EXCEPT AS NOTED)

R&D spending by small firms in 2018[1]	3600
Effective Subsidy Rate[2]	32.1%
Tax revenue forgone[3]	1052
Price elasticity of demand	-1.40
Subsidy-induced change in R&D	1078
Spillover rate (% of induced R&D)[3]	19.0%
Benefits	
Lower production costs from spillovers	204.9
Costs	
Lower private return on R&D	-164.7
Lower export prices of commercialized R&D	-22.5
Administration and compliance costs	-195.3
Total costs	-382.6
Benefits less costs	-177.7
Potential tax increase	-7.1
Net Benefit	-184.7
Percentage of tax revenue forgone	-17.6

1. R&D investment intentions for 2018 multiplied by the estimated share of small firm R&D performers.
2. See Table 1.
3. Includes an adjustment for the lower valuer of tax depreciation allowances.

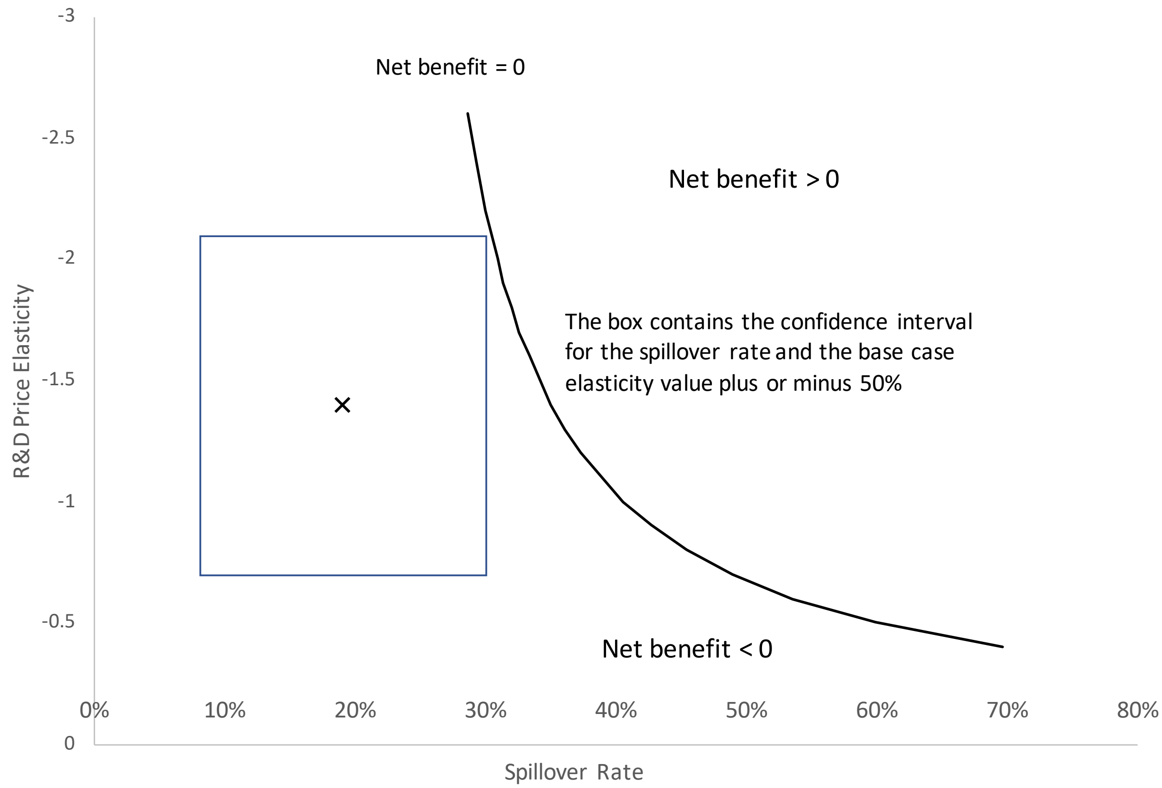
The calculated net benefit is sensitive to assumptions about compliance costs and the spillover rate, but less so with respect to the price elasticity of R&D. Since I found only eight estimates of the price elasticity of demand for small firms, it is difficult to develop an empirically based range of estimates for sensitivity tests. As an illustrative alternative, I varied the elasticity by 50 per cent on either side of the median value from the literature survey. Keeping all other parameters constant, varying the price elasticity over this range causes the net loss to change by at most $17 million or about 10 per cent of the net loss in the base case (Table 10). If the pass-through percentage is reduced to 23 per cent while the price elasticity is increased 50 per cent to -2.1, the net loss declines to $160 million. If administration and compliance costs were the same for small firms as for larger firms, the net loss would be about $65 million, using base case values for other parameters. If lower administration and compliance costs are combined with a higher price elasticity (- 2.1) and a lower pass-through of the subsidy to export prices (23 per cent), the net loss is reduced to about $45 million.

TABLE 10: NET BENEFIT FROM THE ENHANCED SR&ED INVESTMENT TAX CREDIT -- SENSITIVITY TESTS (MILLIONS OF DOLLARS)

	R&D Price Elasticity		
Price pass-through %	-0.70	-1.40	-2.10
23	-191	-174	-160
42	-202	**-185**	-171
65	-215	-198	-185

The message from the preceding sensitivity analysis is that if the spillover rate is assumed to be accurate, it is highly likely that the net benefit from the small-firm SR&ED subsidy is negative. Varying the spillover rate over its 90 per cent confidence interval with all other parameters kept constant changes the net loss to $60 million at the high end (30 per cent) and to $310 million at the low end (eight per cent). Chart 3 illustrates the finding that obtaining a positive net benefit requires some combination of a spillover rate above the upper end of the confidence interval and an R&D price elasticity that exceeds the median value found in the literature survey by more than 50 per cent.

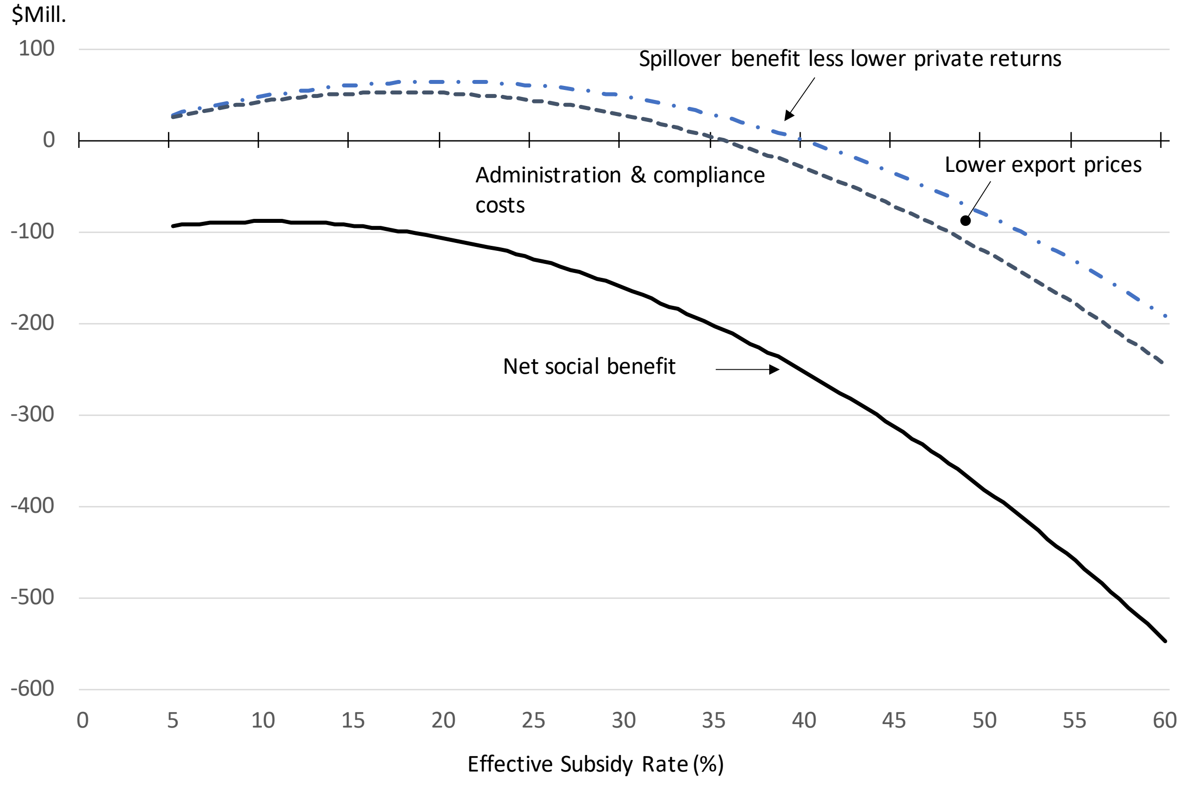
CHART 3: FEDERAL SMALL FIRM SR&ED SUBSIDY -- SENSITIVITY ANALYSIS



The optimal subsidy rate and the contribution of various elements to the net benefit are shown in Chart 4.[26] Considering only the spillover benefit and the cost of subsidy-induced reductions in the private return to R&D, the optimal rate is equal to the 19 per cent spillover rate (top line.) The optimal rate is reduced to about 17 per cent by the partial transfer of the subsidy to foreigners. Administration and compliance costs have a substantial impact on the optimal rate, reducing it to 10 per cent. Setting the small-firm subsidy rate at its optimal value would reduce the net loss from $185 million to $90 million. The net benefit does not change rapidly as the subsidy rate varies around the optimal rate, changing less than 10 per cent as the subsidy rises from 10 to 18 per cent.

Since the small-firm subsidy fails a benefit-cost test even when the subsidy rate is set at its optimal value, it is tempting to conclude that it should be eliminated. There are, however, two reasons for maintaining a subsidy for R&D performed by small firms. First, as discussed earlier, R&D subsidies are an indirect way of offsetting some of the disadvantages faced by small firms. Second, a few small firms are the source of innovations that have big impacts on living standards that are not captured in the spillover analysis. Although these factors cannot be quantified, they suggest reducing rather than eliminating the small-firm subsidy is the prudent policy approach.

CHART 4: DECOMPOSITION OF THE NET SOCIAL BENEFIT OF THE FEDERAL SMALL FIRM R&D SUBSIDY



26 Note that firms do not participate in the program until the subsidy rate exceeds the average cost of compliance, which is 4.6 cents per dollar of investment.

PROVINCIAL SMALL-FIRM SUBSIDIES

The weighted average effective subsidy rate provided by provincial governments on R&D performed by small firms is 6.8 per cent, after factoring in exclusion of provincial subsidies from the federal base. Since the effective federal subsidy rate on R&D performed by small firms is substantially higher than the optimal rate, the additional provincial subsidies add to the net loss created by the federal program. Increasing the federal small business credit rate by 6.8 percentage points would raise the net loss by $65 million. The social cost of the provincial programs would be higher than this because of interprovincial shifting of R&D induced by varying subsidy rates. In addition, administration and compliance costs are likely to be higher, particularly in Quebec which administers its own program.

While this result makes it clear that a co-ordinated elimination of provincial small firm R&D subsidies would raise income in all participating provinces, unilateral elimination would also provide a net benefit for the residents of the initiating province. To demonstrate this point, I analyze the impact of the small-firm subsidies in Quebec, where they are the highest, and in Ontario, where they are the lowest. To simplify the presentation, I analyze the impact of implementing rather than eliminating the existing subsidies in each of these two provinces. The analysis focuses on the net benefit to provincial residents, which can differ from the national impact because of subsidy-induced shifts in R&D spending.

The other key assumptions made in the analysis are:

1. Interprovincial shifting of activity raises the price elasticity of demand for R&D by 25 per cent to - 1.75. The gross-up factor is one-third the value used for large firms, reflecting less ability by small firms to shift R&D activity across provinces.
2. Interprovincial trade raises the export share of R&D-intensive products from 10 per cent to 12.5 per cent.
3. The percentage pass-through of the subsidy in prices is increased from 42 per cent to 48 per cent, reflecting a 50 per cent increase in the elasticity of supply of R&D-intensive products.
4. Administration expenses of Quebec's provincially run program are assumed to be 35 per cent higher per dollar of subsidy than for the federal program, due to its smaller scale. Administration expenses per dollar of subsidy for the Ontario program, which is administered by the Canada Revenue Agency, are assumed to be 10 per cent of the federal cost.
5. Compliance costs per dollar of provincial subsidy received are assumed to be 20 per cent of the federal rate in Quebec, which has a different definition of eligible expenditures, and 10 per cent of the federal rate in Ontario, which uses the federal definition of eligible spending.

Quebec offers the most generous small firm SR&ED subsidy rate, equivalent to 11.9 per cent of investment in R&D after adjustment for exclusion of the provincial subsidy from the federal base. With the above assumptions, residents of Quebec lose about 18 cents on each dollar of subsidy provided (Table 11) and would gain this amount if the provincial subsidy were unilaterally eliminated. This is lower than the 22 per cent loss on the federal program operating in Quebec. The spillover benefit in the Quebec program is disproportionately large due to the interprovincial shifting of activity and compliance costs are substantially lower.[27] On the other hand, the private rate of return on R&D declines more than proportionately with increases in the subsidy rate.[28] The combined federal-Quebec effective subsidy rate is 44 per cent, which causes the marginal impact of the Quebec program on the private rate of return on R&D to be almost the same as the impact of the substantially more generous federal program (Table 11). The transfer of the subsidy to non-residents through lower "export" prices is also almost the same as the amount transferred under the federal program.

TABLE 11: NET BENEFIT TO QUÉBEC RESIDENTS FROM THE SR&ED SUBSIDIES FOR SMALL FIRMS ($ MILLIONS, EXCEPT AS NOTED)

	Federal Program in Québec	**Federal Plus Québec Program**	**Québec Program**
R&D Investment by small firms[1]	1027	1027	1027
Effective Subsidy Rate[2]	32.1%	44.0%	11.9%
Effective revenue rate[3]	23.6%	40.3%	16.7%
Fiscal cost of the subsidy	242	414	172
Price elasticity of demand	-1.40	-1.50	-1.75
Spillover rate (% of induced R&D)	19.0%	19.0%	19.0%
Induced R&D	269	397	128
Benefits			
Lower production costs from spillovers	51.2	75.5	24.4
Costs			
Lower private rate of return on R&D	-42.2	-80.4	-38.3
Lower export prices of commercialized R&D	-4.1	-7.7	-3.6
Administration and compliance costs	-55.7	-67.4	-11.7
Total costs	-102.0	-155.6	-53.6
Benefits less costs	-50.9	-80.1	-29.2
Potential tax increase	-1.4	-3.8	-2.4
Net Benefit	-52.2	-83.9	-31.6
Percentage of tax revenue forgone	-21.6	-20.3	-18.4

1. R&D investment intentions for 2018 multiplied by the estimated share of small firm R&D performers.
2. See Table 1. In Québec there is a 30% wage subsidy for small firms (15% for outsourced R&D), which is equivalent to a 19.2% subsidy on the base for the federal credit. The exclusion of the Québec subsidy from the base for the federal credit is captured in a lower Québec subsidy rate.
3. Both rates include an adjustment for a reduced base for tax depreciation allowances. The federal rate includes adjustments for deductibility of the Quebec credit.

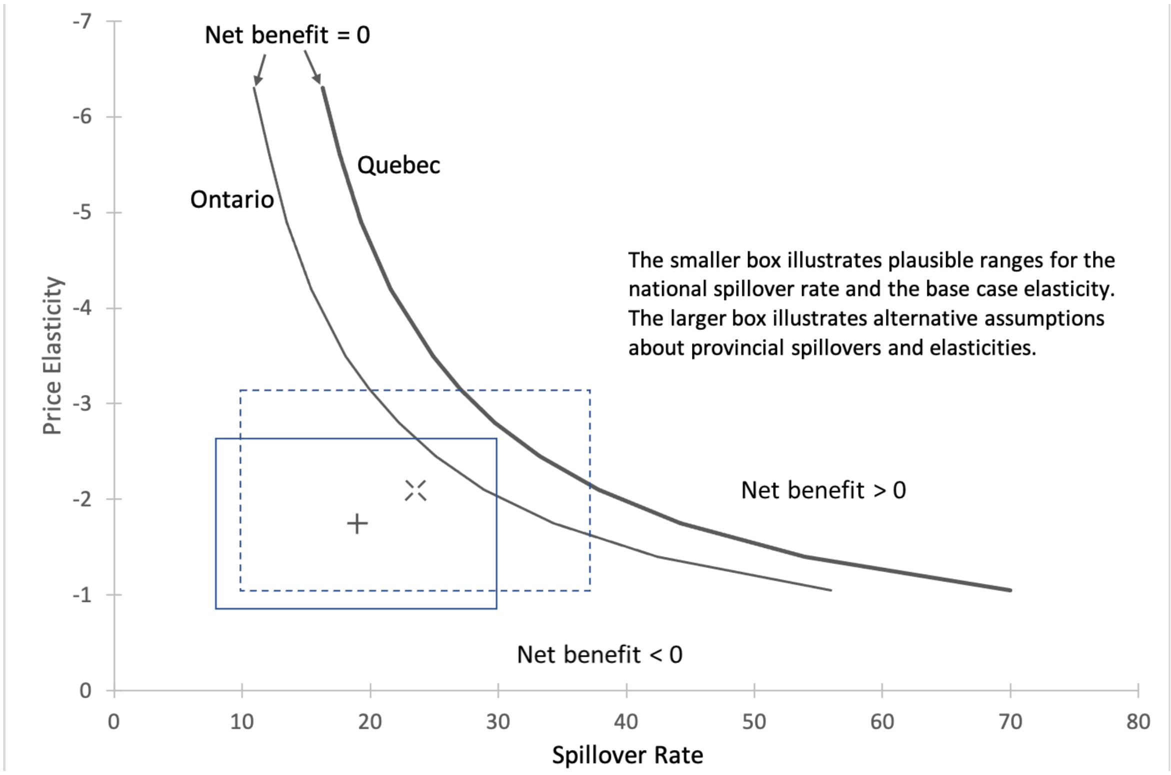
27 If the R&D price elasticity in Quebec is set equal to the national value, the net loss rises to 21 per cent of the tax revenue forgone.

28 Recall that the efficiency loss arising from lower private returns is measured as the change in producer surplus calculated using a simple version of the Harberger triangle methodology. The formula used is $(.5 \cdot s^2 \cdot \varepsilon \cdot R\&D_t)/((1 - s \cdot \varepsilon))$, where s is the subsidy rate, and ε is the absolute value of the price elasticity of demand for R&D. The loss in producer surplus rises with the square of the subsidy rate.

To test the robustness of the finding of a net social loss from the Quebec R&D incentive for small firms, I performed sensitivity tests by varying national and provincial parameters. Increasing the national spillover rate to the top end of the confidence interval (30 per cent) and setting the national price elasticity at its most favourable values within the subjectively defined plausible range — -2.1 which implies a provincial price elasticity of -2.63 — is not sufficient to generate a positive net benefit. Chart 5 illustrates this outcome. The smaller box in the chart contains the confidence interval for the national spillover rate and provincial price elasticities ranging from -.875 to -2.63, which are the national values grossed up by 25 per cent. None of the spillover and elasticity combinations results in a positive net benefit for the Quebec subsidy.

As discussed in the analysis of Ontario's large-firm credit, it is possible that the greater R&D intensity and greater diversity of R&D spending results in a higher spillover rate in Quebec. Assuming that the national spillover rate is at the top end of its confidence interval — 30 per cent — a plausible upper limit for the spillover rate in Quebec is about 37 per cent. This estimate is based on the assumptions that the spillover rate in Ontario would be similar and that the spillover rate in the other provinces should be at least 10 per cent.[29] To develop an upper limit to the provincial price elasticity, I multiply the national values by 1.5, which gives a range of -1.05 to -3.15. The possible combinations of these spillover and elasticity values are represented by the larger box in Chart 5. Just under 10 per cent of the combinations generate a positive net benefit for the Quebec incentive.

CHART 5: QUEBEC AND ONTARIO SMALL FIRM SR&ED SUBSIDIES SENSITIVITY ANALYSIS



29 Quebec and Ontario account for 29 and 44 per cent, respectively, of the R&D performed in Canada. A 37 per cent spillover rate in these two provinces implies a 10 per cent spillover rate in other provinces, on average.

These sensitivity tests indicate that both the spillover rate and the price elasticity of demand, which measures the combined effect of additional R&D by Quebec-based firms and shifting of activity from other provinces, must be at the high end of their ranges for the Quebec incentive to generate a positive net benefit.

Small firms performing R&D in Ontario may receive a 3.5 per cent non-refundable tax credit and an eight per cent refundable tax credit, or subsidy, on eligible spending. Assuming no small firms can take advantage of the non-refundable tax credit, the effective subsidy rate on R&D spending by small firms is five per cent, after adjustment for the exclusion of the provincial subsidy from the federal base. With the assumptions set out above, the Ontario government loses about 13 cents per dollar of subsidy provided compared to a 19 per cent loss for the federal program in Ontario (Table 12). The smaller loss relative to the federal program in Ontario is the result of higher spillover benefits and substantially lower administration and compliance costs per dollar of subsidy that are only partially offset by the subsidy-induced decline in the private rate of return.

TABLE 12: NET BENEFIT TO ONTARIO RESIDENTS FROM THE SR&ED SUBSIDIES FOR SMALL FIRMS ($ MILLIONS, EXCEPT AS NOTED)

	Federal Program in Ontario	Federal Plus Ontario Program	Ontario Program
R&D Investment by small firms[1]	1580	1580	1580
Effective Subsidy Rate[2]	32.1%	37.1%	5.0%
Effective revenue rate[3]	26.9%	34.0%	7.1%
Fiscal cost of the subsidy	424	536	112
Price elasticity of demand	-1.40	-1.45	-1.75
Spillover rate (% of induced R&D)	19.0%	19.0%	19.0%
Induced R&D	447	535	88
Benefits			
Lower production costs from spillovers	84.9	101.7	16.8
Costs			
Lower private rate of return on R&D	-68.9	-93.2	-24.3
Lower export prices of commercialized R&D	-9.2	-12.7	-3.4
Administration and compliance costs	-85.7	-87.7	-2.0
Total costs	-163.9	-193.6	-29.7
Benefits less costs	-79.0	-91.9	-12.9
Potential tax increase	-2.5	-4.1	-1.5
Net Benefit	-81.5	-96.0	-14.5
Percentage of tax revenue forgone	-19.2	-17.9	-12.9

1. R&D investment intentions for 2018 multiplied by the estimated share of small firm R&D performers.
2. See Table 1. The exclusion of the Ontario subsidy from the base for the federal credit is captured in a lower Ontario subsidy rate.
3. Both rates include an adjustment for a reduced base for tax depreciation allowances. The federal rate includes an adjustment for deductibility of the Ontario credit.

Ontario's small firm R&D subsidy is slightly more likely to be providing a net benefit than the Quebec program. About five per cent of the plausible combinations of national spillovers and elasticities results in a positive net benefit (Chart 5, smaller box). Using the province-specific values developed for Quebec, the probability rises to about 25 per cent (Chart 4, larger box).

POLICY RECOMMENDATIONS

The national net benefit of subsidizing R&D would be maximized if provincial governments eliminated their programs and the federal government set the large- and small-firm credit rates at their optimal values. A single national program would minimize administration and compliance costs and would eliminate subsidy-driven interprovincial shifts in R&D, which reduce efficiency.

A second-best solution would be to set the combined federal-provincial subsidy rates close to their optimal values with uniform provincial rates. The estimated optimal effective subsidy rate for large firms is 25.5 per cent, which implies a combined federal-provincial statutory rate of 28 per cent. The actual combined statutory rate is 20.1 per cent (Table 13). Raising the federal rate to 20 per cent and the weighted average provincial rate from six to 10 per cent would put the combined statutory rate at its optimal value. The best way to increase the provincial weighted average rate would be for Ontario to raise its large-firm rate from 3.5 to 10 per cent, and for Alberta to implement a 10 per cent credit rate. With these changes, the statutory rate would be at or close to 10 per cent in B.C., Alberta, Ontario and Quebec, which account for 95 per cent of R&D performed in Canada (Table 2).

TABLE 13: ACTUAL AND PROPOSED FEDERAL AND PROVINCIAL SR&ED INVESTMENT TAX CREDIT STATUTORY RATES (IN PERCENTAGE)

	Federal	Provincial[1]	Combined[2]
Small firms[3]			
Actual	35.0	10.9	42.1
Proposed	10.0	10.0	19.0
Large firms			
Actual	15.0	6.0	20.1
Proposed	20.0	10.0	28.0

1. Expenditure-weighted sum of provincial stautory rates.
3. The base for the federal credit is reduced by the amount of provincial assistance provided.
3. Canadian-controlled private corporations.

The optimal R&D effective subsidy rate for small firms is 10 per cent, which is consistent with a combined federal-provincial statutory rate of 11 per cent. The actual combined rate is 42.1 per cent. Reducing the federal rate to 10 per cent would lower the combined rate to 19 per cent. While this would be almost double the optimal rate, the cost of exceeding the optimal rate by this amount is small, abstracting from the effects of provincial variation in rates. Quebec would benefit from lowering its small-firm subsidy rate from 19.2 per cent to 10 per cent[30] and the consequent reduction in interprovincial variation in rates would improve national economic efficiency.

CONCLUSION

The main policy message arising from the analysis in this paper is that tax credits for R&D should be increased for large firms and reduced for smaller firms. Substantial income gains would be realized if the federal government increased the large-firm credit rate to 20 per cent and reduced the small-firm subsidy rate to 10 per cent. The gain would be even more substantial if provincial governments, including Alberta, adopted a common subsidy rate of 10 per cent for all firms.

Ontario and Quebec are the only provinces that subsidize R&D performed by small firms at a higher rate than R&D performed by large firms. Residents of these provinces would experience a real income gain by eliminating this preferential treatment.

30 As shown in Table 2, Quebec's small-firm statutory rate of 30 per cent is equivalent to 19.2 per cent on the base for the federal credit.

REFERENCES

Australia Industry Commission. 1995. "Research and Development." Report 44. Australian Government Publication Service.

Australian Bureau of Industry Economics. 1993. "R&D, Innovation and Competitiveness: An Evaluation of the Research and Development Tax Concession." Research Report 50. Australian Government Publication Service.

Baylor, M., and L. Beauséjour. 2004. "Taxation and Economic Efficiency: Results from a Canadian CGE Model." Department of Finance.

Bernstein, J. I. 1988. "Costs of Production, Intra-and Interindustry R&D Spillovers: Canadian Evidence." *Canadian Journal of Economics*, 324–347.

Bloom, N., M. Schankerman, and J. Van Reenen. 2013. "Identifying Technology Spillovers and Product Market Rivalry," *Econometrica* 81, 1347–1393.

Boadway, R., and M. Keen. 2006. "Financing and Taxing New Firms under Asymmetric Information." *FinanzArchiv: Public Finance Analysis* 62, 471–502.

Braido, L.H., C. E. da Costa, and B. Dahlby. 2011. "Adverse Selection and Risk Aversion in Capital Markets." *FinanzArchiv: Public Finance Analysis* 67, 303–326.

Brander, J. A., E. Egan, and T. F. Hellmann. 2010. "Government Sponsored versus Private Venture Capital: Canadian Evidence." In *International Differences in Entrepreneurship*, J. Lerner and Antoinette Shoar, eds. 275–320. Chicago: University of Chicago Press.

Carrière, B. 2014. "2002-2012: A Decade of Change in Canadian Manufacturing Exports." Analytical paper. 11-621–M, no. 92.

Cerulli, G., and B. Potì. 2012. "The Differential Impact of Privately and Publicly Funded R&D on R&D Investment and Innovation: The Italian Case." *Prometheus* 30, 113–149.

Clausing, K. A. 2001. "Trade Creation and Trade Diversion in the Canada–United States Free Trade Agreement." *Canadian Journal of Economics/Revue Canadienne d'économique* 34, 677–696.

Clendenning, E.W. 2000. "Comparison and Reconciliation of SIC and NAICS Industry Codes Used to Define Knowledge-based Industries (KBIs)." Prepared for Industry Canada, Small Business Policy Branch.

Cornet, M. 2001. "De maatschappelijke kosten en baten van technologiesubsidies zoals de WBSO." CPB, Netherlands.

Dahlby, B. 2005. "A Framework for Evaluating Provincial R&D Tax Subsidies." *Canadian Public Policy/Analyse de Politiques*, 45–58.

Erkel-Rousse, H., and D. Mirza. 2002. "Import Price Elasticities: Reconsidering the Evidence." *Canadian Journal of Economics/Revue Canadienne d'économique* 35, 282–306.

Ferede, E., and B. Dahlby. 2016. “The Costliest Tax of All: Raising Revenue through Corporate Tax Hikes Can Be Counter-Productive for the Provinces.” *SPP Research Paper* 9.

Finance Canada and Revenue Canada. 1997. “The Federal System of Income Tax Incentives for Scientific Research and Experimental Development: Evaluation Report.”

Fowkes, R. K., J. Sousa, and N. Duncan. 2015. “Evaluation of Research and Development Tax Credit.” HMRC Working Paper.

Goolsbee, A. 1998. “Does Government R&D Policy Mainly Benefit Scientists and Engineers?” National Bureau of Economic Research.

Guceri, I. 2018. “Will the Real R&D Employees Please Stand Up? Effects of Tax Breaks on Firm-level Outcomes.” *International Tax and Public Finance* 25, 1–63.

Guceri, I., and L. Liu. 2019. “Effectiveness of Fiscal Incentives for R&D: Quasi-experimental Evidence.” *American Economic Journal: Economic Policy* 11, 266–91.

Hall, B. H., J. Mairesse, and P. Mohnen. 2010. “Measuring the Returns to R&D.” *Handbook of the Economics of Innovation* 2, 1033–1082.

Imbs, J., and I. Mejean. 2015. “Elasticity Optimism.” *American Economic Journal: Macroeconomics* 7, 43–83.

Industry Canada. 2011. *Survey on Financing and Growth of Small and Medium Enterprises.*

Kasahara, H., K. Shimotsu, and M. Suzuki. 2014. “Does an R&D Tax Credit Affect R&D Expenditure? The Japanese R&D Tax Credit Reform in 2003.” *Journal of the Japanese and International Economies* 31, 72–97.

Kim, M., and J. Lester. 2019. “R&D Spillovers in Canadian Industry: Results from a New Micro Database.” Research Report 2019–02. Centre for the Study of Living Standards.

Kobayashi, Y. 2014. “Effect of R&D Tax Credits for SMEs in Japan: A Microeconometric Analysis Focused on Liquidity Constraints.” *Small Business Economics* 42, 311–327.

Lach, S. 2002. “Do R&D Subsidies Stimulate or Displace Private R&D? Evidence from Israel.” *The Journal of Industrial Economics* 50, 369–390.

Lattimore, R. 1997. “Research and Development Fiscal Incentives in Australia: Impacts and Policy Lessons.” In *OECD Conference on Policy Evaluation in Innovation, Paris*, 26: 574–577.

Lee, H., and S. K. Markham. 2016. “PDMA Comparative Performance Assessment Study (CPAS): Methods and Future Research Directions.” *Journal of Product Innovation Management* 33, 3–19.

Lester, J. 2012. “Benefit-cost Analysis of R&D Support Programs.” *Canadian Tax Journal/Revue Fiscale Canadienne* 60.

———. 2017. “Policy Interventions Favouring Small Business: Rationales, Results and Recommendations.” *University of Calgary School of Public Policy Research Paper* 10, 55.

———. 2018a. “Business Subsidies in Canada Comprehensive Estimates for the Government of Canada and the Four Largest Provinces.” *The School of Public Policy Research Paper* 11, 34.

———. 2018b. “Tax Incentives for Business Investment: Do They Work?” In *Reforming the Corporate Tax in a Changing World*, Bev Dahlby, ed. 259. Canadian Tax Foundation and the School of Public Policy, Calgary.

Lester, J., and J. Warda. 2018. “An International Comparison of Tax Assistance for R&D: 2017 Update and Extension to Patent Boxes.” *The School of Public Policy Publications* 11, 36.

———. 2020. “Enhanced Tax Incentives for R&D would Make Americans Richer.” Information Technology & Innovation Foundation.

Li, W. C., and Bronwyn H. Hall. 2016. “Depreciation of Business R&D Capital.” *Review of Income and Wealth* 66 (1): 161–180.

Lokshin, B., and P. Mohnen. 2013. “Do R&D Tax Incentives Lead to Higher Wages for R&D Workers? Evidence from the Netherlands.” *Research Policy* 42, 823–830.

Lucking, B., N. Bloom, and J. Van Reenen. 2017. “Have R&D Spillovers Changed?” *Fiscal Studies* 40 (4): 561–590.

McKenzie, K. J., and E. Ferede. 2017. “Who Pays the Corporate Tax? Insights from the Literature and Evidence for Canadian Provinces.” *SPP Research Papers* 10 (6).

Moon, Y.-E., and J. Yoon. 2004. “Innovation Management in the Australian Government: Cost and Benefit of R&D Tax Concession Program.” *Korea Science*. The Korea Society of Digital Policy and Management, 95–118.

Ornaghi, C. 2006. “Spillovers in Product and Process Innovation: Evidence from Manufacturing Firms.” *International Journal of Industrial Organization* 24, 349–380.

Parsons, M., and N. Phillips. 2007. “An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development.” Department of Finance, Economic and Fiscal Policy Branch.

Picot, G., and Y. Ostrovsky. 2017. “Immigrant Businesses in Knowledge-based Industries.” 069. *Economic Insights*. Statistics Canada.

Rao, N. 2016. “Do Tax Credits Stimulate R&D Spending? The Effect of the R&D Tax Credit in its First Decade.” *Journal of Public Economics* 140: 1–12.

Romalis, J. 2007. “NAFTA’s and CUSFTA’s Impact on International Trade.” *The Review of Economics and Statistics* 89, 416–435.

Russo, B. 2004. “A Cost-benefit Analysis of R&D Tax Incentives.” *Canadian Journal of Economics/Revue Canadienne d’économique* 37, 313–335.

Seens, D. 2015. *SME Profile: Canadian Exporters*. Industry Canada.

Sterlacchini, A., and F. Venturini. 2019. "R&D Tax Incentives in EU Countries: Does the Impact Vary with Firm Size?" *Small Business Economics* 53, 687–708.

Svensson, R. 2007. "Commercialization of Patents and External Financing during the R&D Phase." *Research Policy* 36, 1052–1069.

Weyl, E. Glen, and Michal Fabinger. 2013. "Pass-through as an Economic Tool: Principles of Incidence under Imperfect Competition." Journal of Political Economy 121 (3): 528–583.

Wolff, G. B., and V. Reinthaler. 2008. "The Effectiveness of Subsidies Revisited: Accounting for Wage and Employment Effects in Business R&D." *Research Policy* 37, 1403–1412.

ANNEX A: KEY PARAMETERS IN THE BENEFIT-COST MODEL

SPILLOVERS

There is a rich empirical literature on the returns to R&D covering both the rate of return to the firm performing the R&D and the spillover benefits to other firms. Researchers typically estimate the parameters of a production or cost function that includes the owned stock of R&D, tangible capital and labour as inputs, and some measure of R&D that is external to the firm as an additional factor affecting output. A positive coefficient on the stock of external R&D, or the spillover pool, indicates that that firms benefit from the knowledge created by other firms.

The spillover benefit used in the benefit-cost analysis is therefore the change in aggregate output per dollar increase in the R&D spillover pool. Since the level of conventional inputs is held constant, the spillover benefit can be described as an increase in productivity. This may strike some as an incomplete measure since the spillover benefit allows firms to improve existing products and introduce new products as well as to reduce production costs.

However, if prices are correctly measured, the change in real output captures the complete spillover benefit. The return to bringing a new product to market is shared by the producer, who gets extra revenue, and consumers, who on average value the product at more than the selling price. Quality-adjusted consumer prices fall when improvements are made to existing products and when new products are introduced, which results in higher real output. While it is common practice to adjust prices for quality changes and the introduction of new products, an upward bias remains in existing price indexes.

In my 2012 paper, I used the median value from a literature survey prepared by Parsons and Phillips (2007), who found eight studies reporting spillover estimates for Canada. The median value was 56 per cent, which implies that a dollar spent on R&D by one firm reduces costs of other firms by 56 cents. Results for other countries imply lower spillover rates. The median spillover rate in 20 studies included in the review by Hall, Mairesse and Mohnen (2010) is 28 per cent. Kim and Lester (2019) found six studies prepared after the survey by Hall, Mairesse and Mohnen in which spillover rates were reported or could be calculated. Including the Kim-Lester (2019) result, the median spillover rate in the seven studies is 33 per cent. The median spillover rate for all 27 studies is 29 per cent.

Most of these studies measure the positive knowledge spillovers only; they do not capture the negative product market rivalry or business-stealing effect. The exceptions are studies by Bloom, Schankerman and Van Reenen (2013) and Lucking, Bloom and Van Reenen (2017), which provide convincing evidence that the spillover benefit remains positive when product market rivalry effects are included in the analysis. The two studies, which apply the same methodology to different samples, find a net spillover benefit of 34 per cent and 44 per cent respectively, which are larger than the median value found in the literature survey. Product market rivalry effects reduce knowledge spillovers by about 10 percentage points in both studies.

The empirical work by Kim and Lester (2019) fills three gaps in the spillover literature. First, it uses firm-level data for all R&D performers in Canada. The only study of R&D spillovers using Canadian firm-level data was prepared 32 years ago by Bernstein (1988), covering selected manufacturing industries. Second, it is one of two spillover studies that define the spillover pool using a measure of technological proximity based on firms' reported expenditure by research field. This approach has a considerable advantage over the more usual approach of defining proximity in terms of patenting activities since it allows all R&D performers to be included in the analysis. Third, it is one of three studies that analyze spillovers by size of firm. One of these studies (Bloom, Schankerman and Van Reenen 2013) includes only publicly listed firms, which excludes many small firms. The median number of employees per firm in the bottom quartile of the sample is 370. Ornaghi (2006) provides spillover elasticities for a complete range of firm sizes, but not spillover rates.

Kim and Lester (2019) estimate the spillovers generated by firms eligible for the 35 per cent subsidy and by other firms. The spillover rate for R&D performed by small firms is estimated at 19 per cent, which is a bit more than a third of the 52 per cent spillover rate for R&D performed by large firms.[31] The all-firm spillover rate is 33 per cent, which is at the 60th percentile in the 26 studies included in the Kim-Lester (2019) literature review. I use the Kim-Lester (2019) results in the base case benefit-cost analysis because they provide unique information on spillover rates by size of firm.

THE RESPONSIVENESS OF R&D TO SUBSIDIES

The amount of additional R&D induced by the tax credits is a key element of the benefit-cost analysis: for subsidy rates close to or below the optimal rate, the higher the responsiveness to a subsidy, the higher the net benefit.[32] Studies examining the response to tax credits typically examine the relationship between the percentage change in the price of R&D arising from the subsidy and the percentage change in the amount of R&D performed — the price elasticity of R&D. Unitary price elasticity means that the price and the amount of R&D performed change by the same percentage. This relationship implies that the amount of R&D induced by a small change in the tax credit is equal to the amount of tax revenue forgone — that is, self-financed private R&D spending does not change. A price elasticity of less than one (in absolute value) indicates crowding out of private spending, while a price elasticity greater than one indicates crowding in of private spending on the margin.

The elasticity estimates found in the literature have been criticized for potentially overstating the impact of price changes on the volume of R&D performed, for two reasons. Goolsbee (1998) makes the point that since the supply of researchers responds relatively weakly to increased demand, particularly in the short run, an R&D subsidy is likely to raise the wages of scientists as well as increase the amount of R&D performed. Goolsbee concludes that the wage effect could be causing conventional elasticity

31 The hypothesis that the small- and large-firm spillover rates are the same is rejected. p-value = .000

32 When the subsidy rate is well above the optimal rate, the benefit of performing additional R&D is less than the cost. See the discussion of the provincial small-firm subsidies for additional detail.

estimates to overstate the responsiveness of R&D effort to subsidies by 30 to 50 per cent. However, this conclusion appears to be based on the premise that the elasticity estimates assess the response of nominal, not real, spending on R&D to price changes.

In principle, the elasticity estimates measure the response of the volume, or the real value, of R&D performed to changes in its price. The real value of R&D performed will increase with the number of hours worked by scientists, so the estimated elasticities should move in the same direction as the responsiveness of the supply of researchers to higher demand. High supply responsiveness should result in a high price elasticity and low responsiveness should result in a low elasticity. In practice, however, satisfactory measures of the volume, or real value, of R&D are not always available. Satisfactory deflation of spending on R&D requires tracking the number of researchers employed, their hours worked and their wage rates as well as the prices of capital equipment and intermediate materials used in the performance of R&D. In many cases, the price deflator used does not capture all these elements. For example, the estimates of real business spending on R&D prepared by the Organisation for Economic Co-operation and Development (OECD) are the nominal values of spending divided by the deflator for gross domestic product.

Since the real value of R&D is mismeasured in many of the studies summarized in Table A1, the elasticities are likely mismeasured as well. However, since the measurement error could be positive or negative, the estimated elasticities could be higher or lower than if they were derived from correctly measured real R&D.

The second criticism made of the estimated price elasticities is that they could be overstated because firms may relabel ordinary spending as spending on R&D or shift R&D spending from non-qualifying to qualifying categories to maximize the subsidy received. A perspective on the importance of these effects is provided by work by Guceri (2018) and Guceri and Liu (2019). These two studies assess the impact of enriching the U.K. R&D tax credit[33] using different data bases. Guceri (2018) uses firm responses to the Business Enterprise Research and Development (BERD) survey while the analysis in Guceri and Liu (2019) is based on data submitted by firms to claim R&D tax credits, which may be affected by the relabelling and qualifying expenditure responses. The preferred elasticity estimate from the BERD survey data is -1.18, compared to -1.59 when the tax data are used. The difference in estimates suggests that elasticities obtained from data submitted to claim a subsidy overstate the impact on overall R&D spending.

In the U.S., the Internal Revenue Service reports the components of R&D spending separately. Rao (2016) exploits this information to compare the response of spending that qualifies for tax assistance with spending that does not qualify. She finds that the ratio of qualified to total R&D spending rises with the tax subsidy rate, which likely reflects some combination of relabelling and substitution between qualified and non-qualified spending. However, the results are based on a subsample of the main dataset, causing Rao to describe the results as suggestive rather than definitive.

---

33 Two changes were implemented in 2008: the enhanced subsidy rate for small firms was increased and the firm size thresholds for qualifying for enhanced assistance were doubled. Firms newly qualifying for the enhanced credit experienced a 17 per cent reduction in the user cost of R&D capital.

Table A1: Long-run R&D Price Elasticity Estimates, 1990-2019									
				All firms		Large Firms		SMEs	
Study	Country	Unit of analysis	Period	Reported	Used (preferred or average)	Reported	Used (preferred or average)	Reported	Used (preferred or average)
Dagenais, Mohnen & Therrien (1997)	Canada	Firm panel	1975-92	-1.08	-1.08				
Lebeau (1996)	Canada (Quebec)	Firm panel	1977-93	-0.965	-0.97				
Nadiri & Kim (1996)	Canada	Country	1964-91	-1.01	-1.01				
Wilson (2005)	US	State R&D	1981-04	-2.2	-2.2				
Mamuneas & Nadiri (1996)	US	15 Industries	1956-88	-.84 to -1	-0.92				
Nadiri & Kim (1996)	US	Country	1964-91	-1.09	-1.09				
Berger (1993)	US	Firm panel	1982-85	-1.0 to -1.5	-1.25				
Hall (1993)	US	Firm panel	1981-91	-2.0 to -2.7	-2.35				
Hines, Hubbard & Slemrod (1993)	US	Multinational firms	1984-89	-1.2 to -1.6	-1.4				
Rao (2016)	US	firm level	1989-90	-1.937	-1.937				
Harris, Li & Trainor (2009)	Northern Ireland	Firm cross-section	1998-03	-1.36	-1.36				
Nadiri & Kim (1996)	France	Country	1964-91	-1.05	-1.05				
Mairesse & Mulkay (2004)	France	Firm cross-section	1983-97	-2.68 to -2.78	-2.73				
Mulkay & Mairesse (2013)	France	Firm panel	2000-07	-0.4	-0.4				
Parisi & Sembellini (2003)	Italy	Firm panel	1992-97	-1.5 to -1.77	-1.64				
Nadiri & Kim (1996)	Italy	Country	1964-91	-1.02	-1.02				
Poot et al (2003)	Netherlands	Firm cross-section	1997-98	-1.12	-1.12				
Nadiri & Kim (1996)	Germany	Country	1964-91	-1.11	-1.11				
Nadiri & Kim (1996)	Japan	Country	1964-91	-1.05	-1.05				
Nadiri & Kim (1996)	UK	Country	1964-91	-1.04	-1.04				
Fowkes, Sousa & Duncan (2015)	UK	Firm panel	2003-12	-1.5 to -2	-1.96				
Bloom et al (2002)	G7, Australia & Spain	Country	1979-97	-1.09	-1.09				
McKenzie & Sershun (2005)	G7, Australia & Spain	Country	1979-97	-0.7 to -0.9	-0.8				
Appelt, Galindo-Rueda & Cabral (2019)	OECD countries	Country	2000-16	-0.84	-0.84				
Westmore (2013)	19 OECD countries	Country	1983-2008	-1	-1				
Baghana & Mohnen (2009)	Canada (Quebec)	Firm panel	1997-2003			*-0.102* [1]	0	-0.191	-0.191
Agrawal, Rossel & Simcoe (2019)	Canada	Firm panel	2000-07					-.71 to -4.57	-2.64
Koga (2003)	Japan	Firm panel	1989-98	-0.68	-0.68	-1.03	-1.03	*-0.119* [1]	0
HMRC (2010)	UK	Firm panel	2000-07			-0.82 [2]	-0.82	-2.41	-2.41
Dechezleprêtre et al (2016)	UK	Firm panel	2006-11					-2.56 to -3.51	-2.63
Guceri (2018)	UK	Firm panel	1999-2013					-.88 to -1.18	-1.18
Guceri & Liu (2019)	UK	Firm panel	2002-11					-1.59 to -2.27	-1.59
Lokshin & Mohnen (2012)	Netherlands	Firm panel	1996-2004	-0.8	-0.8	-0.25	-0.25	-1.1	-1.1
Counts					27		4		8
Median values									
All					-1.08		-0.535		-1.385
Canada Only					-1.01				
US Only					-1.40				
All other					-1.05				

1. Not significantly different from zero.
2. Semi-elasticity of -3.65 transformed to an elasticity by the author of this study.

A review of the literature turned up 35 studies prepared since 1993 with usable price elasticity estimates (Table A1).[34] The median value of estimated elasticities applying to all firms is -1.08. I found eight studies providing usable elasticity estimates for small firms. The median estimate in these studies is -1.39. Empirical work also shows that credit-constrained firms respond more strongly to subsidies than other firms (Cerulli and Potì 2012; Kasahara, Shimotsu and Suzuki 2014; Kobayashi 2014; Fowkes, Sousa and Duncan 2015). As a result, the higher responsiveness of smaller firms may reflect the fact that they are more likely to be credit-constrained than large firms.

The median estimate for smaller firms should, however, be used cautiously. Several studies that did not include elasticity estimates report the ratio of the change in R&D spending to the amount of tax revenue forgone, or cost-effectiveness ratios (CERs), that indicate lower responsiveness of smaller firms. Lach (2002), working with Israeli manufacturing firms, obtains a substantially higher CER for larger firms than for all firms, although both ratios imply a price elasticity greater than one. Sterlacchini and Venturini (2019) report CERs that are lower for smaller firms in the U.K. and France, where both ratios are less than one, but higher in Italy. In contrast, Cerulli and Potì (2012) report a CER for smaller firms in Italy that is not significantly different from one while the CER for large firms is well above one.

Despite these qualifications, in this study I use the median price elasticity for small firms obtained from the literature survey, -1.4. This base case assumption makes it more likely to obtain a positive result in the benefit-cost analysis. Given that large firms account for almost 80 per cent of R&D spending in Canada,[35] an all-firm price elasticity of -1.08 and a small-firm elasticity of -1.4 imply a large-firm price elasticity of – 1.0.[36]

TRANSFER OF THE SUBSIDY TO NON-CANADIANS

The benefit-cost analysis focuses on the benefits to Canadians, who absorb the fiscal cost of the subsidy through higher taxes or lower government services. If the subsidy payments are received by other Canadians, the "tax and spend" operation has no direct impact on Canadians' income. However, if foreigners receive some of the subsidy, Canadians' income is reduced. This could occur through export sales of products and services developed using subsidized R&D and through subsidy-induced profits accruing to foreign-owned firms.[37] While these are important elements of the benefit-cost analysis, limited information on their determinants means that their estimated costs should be considered illustrative.

34 The survey builds on work by Parsons and Phillips (2007) and Fowkes, Sousa and Duncan (2015).

35 Data presented in Kim and Lester (2019) indicate that on average from 2000 to 2012 large firms accounted for 79 per cent of total business investment in R&D.

36 Note that unitary elasticity implies that the prices of inputs do not increase as more R&D is performed.

37 If the subsidy is financed by an increase in the corporate income tax rate, additional tax revenue will also be collected from foreign-owned firms operating in Canada. However, McKenzie and Ferede (2017) present convincing evidence that the effective burden of the corporate income tax is shifted from profits to wages. In a world of highly mobile capital, attempts by a small country such as Canada to increase the tax rate on business capital prompts a capital outflow until the target rate of return on capital is restored. The lower stock of capital reduces the productivity of labour and puts downward pressure on the wage rate.

TERMS OF TRADE EFFECTS

The R&D subsidy reduces costs, but unless Canadian producers can sell as much of their output as they want without affecting prices — unless the demand curve is horizontal — some of the subsidy will be passed through to purchasers in the form of lower prices. To the extent that R&D-intensive products are exported, some of the subsidy will be transferred to foreigners, thereby reducing real income in Canada. How much of the subsidy is transferred depends on the amount of additional R&D induced by the subsidy, the success rate in commercializing R&D projects, the export share of sales and how much prices have to fall in order to sell the additional commercialized products.

Lee and Markham (2016) provide information on the success rate for R&D related to product development.[38] Their study provides estimates by geographic region (North America, Europe and Asia) and by size of firm across all regions. The all-region success rate is 58 per cent for small firms and 66 per cent for large firms. Adjusted for a higher success rate in North America, the commercialization rates would be 65 per cent for small firms and 73 per cent for large firms. The estimate for small firms is consistent with estimates of patent commercialization rates in Sweden developed by Svensson (2007), who reports rates of about two-thirds for firms with 11 to 1,000 employees.

There is no direct information available on the export intensity of R&D performers by size of firm. However, some indirect evidence for small and medium-sized (SMEs) enterprises is available. Knowledge-based industries, as defined by the federal department of Innovation, Science and Economic Development,[39] accounted for almost two-thirds of R&D investment in 2013.[40] Seens (2015) reports that SMEs in knowledge-based industries (KBI) exported 13 per cent of their output in 2011. I estimate the export intensity of non-KBI at about three per cent.[41] If the export intensity of small R&D performers operating in non-KBI is the same as the non-KBI average, the overall export intensity of small R&D performers would be almost 10 per cent.

There is no direct evidence on the export intensity of large firms, either for the overall economy or for R&D performers. However, it is easy to demonstrate that larger firms are more export-intensive than smaller firms. The overall export intensity in the manufacturing sector was approximately 45 per cent in 2011 compared to an export intensity of 13 per cent for SMEs.[42] Large firms account for about 45 per cent

---

38 There is no information available on the relative importance of R&D spending related to product development. However, R&D spending undertaken to create new or improved materials, devices, products and processes accounted for 84 per cent of total R&D spending on average from 2014 to 2017. (Source: Statistics Canada, Table 27-10-0344-01, Business Enterprise In-house Research and Development Expenditures by Nature of Research and Development).

39 For a list of industries in the knowledge-based category, see Clendenning (2000).

40 Calculated using R&D expenditures by industry reported by the Organisation for Economic Co-operation and Development (https://stats.oecd.org/Index.aspx?DataSetCode=BERD_INDU).

41 Seens (2015) reports that the overall export intensity of the SME sector is four per cent. KBI account for about 10 per cent of overall business output. If this share applies to the SME sector, the export intensity of non-KBI would be about three per cent. The KBI share was calculated from Statistics Canada Table 36-10-0434-01 and knowledge-based industries definitions presented in Picot and Ostrovsky (2017).

42 Sources: Industry Canada (2011) and Carrière (2014).

of output in the manufacturing sector,[43] so the export intensity of large firms in the manufacturing sector would have been about 72 per cent in 2011.

An appreciation for the export intensity of large firms performing R&D can be obtained by considering goods-producing and service-producing industries separately. Firms in the manufacturing and mining industries accounted for about 40 and 10 per cent of total business R&D performed in 2013. Four industries (computer, electronic and optical products; aerospace; other machinery and equipment; chemicals) accounted for almost 70 per cent of R&D performed in the manufacturing sector. These industries had overall export intensities ranging from about 62 to 74 per cent. Some of the firms in these industries are SMEs, so the export intensity of large firms would have been higher. An even higher export share likely applies to the mining industry. A plausible assumption is that large firms performing R&D in the goods-producing sector export about three-quarters of their output.

Just over half of business R&D is performed by firms in the service sector. About an eighth of service-sector R&D is performed in industries with a near-zero export intensity (financial, health and education) and another eighth in industries that could have an export intensity on a par with goods (packaged software). Two industries — computer programming, consultancy and related activities; and scientific R&D — account for almost half of R&D performed in the service sector. Output in these industries is performed largely under contract for other firms, so the share of the R&D performed that is exported depends on the export intensity of the purchasing industry. The weighted average export intensity of all sectors excluding those where contracting is prevalent is 63 per cent. In the absence of any information on which industries purchase R&D under contract, I assume that the indirect export intensity of the contracting sector is also 63 per cent.

The final element to be considered in assessing transfers to foreigners is how much of the subsidy is passed through in lower prices to consumers of products embodying R&D. The pass-through percentage depends on the responsiveness of demand and supply to changes in prices and on the degree of competition in the market (Box 1).

The demand elasticity of interest is a sales-weighted average of the elasticities in the domestic and export markets. While there is abundant empirical work on trade price elasticities, I did not find any relevant estimates of the price elasticity of demand in the Canadian market. A common assumption in empirical work is to assume that price elasticities are the same in domestic and export markets, which is reasonable for traded goods and services.

When assessed for relatively narrowly defined industries, empirical estimates of import price elasticities of demand are high. Working with data for OECD countries over the 1972-94 period, Erkel-Rousse and Mirza (2002) report price elasticities for manufacturing industries in the -1 to -7 range. Elasticities for industries producing differentiated products, which are more relevant for industries producing R&D-

---

43 Source: Key Small Business Statistics — January 2019, Department of Innovation, Science and Economic Development (https://www.ic.gc.ca/eic/site/061.nsf/eng/h_03090.html#point5-1).

intensive products, range from -1.2 to -4.2. Imbs and Mejean (2015), working with U.S. imports over the 1996 to 2004 period, report a median price elasticity of -4.1 over 56 manufacturing industries. The authors also report that the elasticities are highest for industries producing differentiated products, although detailed results are not provided in the paper. Clausing (2001) analyzes the 1989-94 tariff reductions on Canadian exports to the U.S. She reports that each percentage point reduction in U.S. tariffs increased imports from Canada by 10 or 11 per cent, depending on the assumptions made. Based on this evidence, I use a demand-price elasticity of -4 for exports and domestic sales of R&D-intensive products in the base case analysis.

Box 1: Pass-through of a Subsidy to Prices

How a broad-based subsidy (or tax) is reflected in selling prices depends on the competitive environment in which the subsidized firms operate. If many firms are selling identical products (i.e., operating in a perfectly competitive market) each will reduce its price by the amount of the subsidy. However, lower prices will stimulate demand, and if the additional output drives up unit production costs, the ultimate impact on prices will be lower. The percentage pass-through of a subsidy depends on how both demand and supply respond to a change in price — the elasticity of demand and supply.

If there is only one seller — a monopoly — the pass-through will be smaller than under perfect competition. In this case, the pass-through depends not only on supply and demand elasticities but also on whether demand responds linearly or non-linearly to price changes — whether the demand curve is a straight line or curved. If the demand curve is a straight line and production can be increased without affecting unit costs, exactly one-half of the subsidy will be passed on to prices. However, if unit costs rise with increased production, the pass-through will be less than 50 per cent for any value of the demand and supply elasticities.

If the market consists of a few (oligopoly) or many firms selling similar rather than identical products (monopolistic competition), which is a reasonable characterization of the market for R&D-intensive products, Weyl and Fabinger (2013) demonstrate that in most, but not all, cases the pass-through percentage will lie between the value under perfect competition and monopoly market conditions. The exceptions occur when the subsidy (or tax) causes a change in the extent of competition in the market.

The general formula developed by Weyl and Fabinger is:

$$\rho = \frac{1}{1 + \frac{\varepsilon_d - \theta}{\varepsilon_s} + \frac{\theta}{\xi_d} + \frac{\theta}{\varepsilon_\theta}}$$

Where ρ = the pass-through percentage; ε_d and ε_s are the absolute values of the elasticity of market demand and supply, respectively; ξ_d indicates whether demand responds linearly or non-linearly to price changes; θ is an indicator of the state of competition; and ε_θ indicates how the competitive environment changes with prices.

The special cases discussed above all assume the competitive environment does not change with the subsidy, so the last term in the denominator drops out. In perfectly competitive markets, $\theta = 0$, so the pass-through is:

$$\rho = \frac{1}{1 + \frac{\varepsilon_d}{\varepsilon_s}}$$

In a monopoly $\theta = 1$ and in the special case above, we assumed that the quantity demanded responds linearly to changes in price — the demand curve is a straight line — so that $\xi_d = 1$. With these parameter values, the pass-through becomes:

$$\rho = \frac{1}{1 + \frac{\varepsilon_d - 1}{\varepsilon_s} + \frac{1}{1}} = \frac{1}{2 + \frac{\varepsilon_d - 1}{\varepsilon_s}}$$

A monopolist will always set a price so that ε_d will be at least one, so the pass-through under monopoly will not exceed 50 per cent.

Under monopolistic competition, θ lies between 0 and 1, so that with the above assumptions the pass-through becomes:

$$\rho = \frac{1}{1 + \frac{\varepsilon_d - \theta}{\varepsilon_s} + \frac{\theta}{1}} = \frac{1}{1 + \theta + \frac{\varepsilon_d - \theta}{\varepsilon_s}}$$

Which converges on the monopoly value from above as θ approaches 1.

I found only one study that provides relevant information on the elasticity of supply. Using data on U.S. imports from Canada and Mexico, Romalis (2007) reports a supply elasticity for traded goods ranging from 3.5 to 4.5.[44] The elasticity of supply of R&D-intensive goods and services could be within, above or below this range, but there is no empirical work or a priori reasoning to help form a view. As a result, I use a supply elasticity of four in the base case analysis.[45]

The next step in calculating the pass-through percentage is to characterize the state of competition in R&D-intensive industries. If many firms were supplying identical products, the market would be classified as perfectly competitive and firms would take the market price as given. Given demand and supply elasticities of -4 and four respectively, half of the subsidy would be passed through to prices (Box 1). However, R&D-intensive industries consist of many firms selling similar but not identical products, a situation often described as monopolistic competition. In this case, each firm sets prices based on its costs, its perceived elasticity of demand for its output[46] and the expected reaction of competing firms. Such firms clearly have more market power than firms operating in perfect competition, but not as much as a monopolist. In the absence of any empirical evidence, I assume in the base case that the degree of competition in R&D-intensive industries is halfway between the situation in perfect competition, where firms have zero market power, and monopoly where market power is highest. If the monopoly market power indicator is set at one, the base case value for the monopolistic market power indicator is .5.

With these assumptions, just over 40 per cent of the subsidy is passed through to prices for both large and small firms. For large firms, the values for the commercialization rate and the export intensity reduce the percentage of the subsidy transferred to foreigners to about 15 per cent, after discounting. For small firms, only about two per cent of the subsidy is transferred to foreigners, largely because the export orientation of small firms is so low.

PROFIT OUTFLOWS

As discussed above, subsidizing R&D puts downward pressure on the market rate of return on R&D. However, the decline in the market rate of return is offset by the subsidy, leaving profits unaffected. To the extent that the subsidy shows up in the profits of foreign-owned firms, the income of Canadians is reduced. On average from 2014 to 2017, foreign-controlled firms accounted for 37 per cent of R&D performed

44 Romalis estimates an inverse supply function over the 1989-99 period using a sample of approximately 5,000 commodities exported to the U.S. The supply curve is identified using U.S. tariffs, which shift the demand curve. The estimated value of the inverse supply elasticity ranges from .22 to .29, with .22 being the preferred estimate.

45 While there is some evidence that the supply of scientists available to undertake R&D does not respond strongly to increased demand (Goolsbee 1998; Wolff and Reinthaler 2008; Lokshin and Mohnen 2013), this effect dampens the response of real spending on R&D to a subsidy but is not relevant when considering the cost of commercializing R&D that has already been completed.

46 Note that the price elasticities discussed above apply to market or industry-level demand rather than demand at the firm level.

in Canada.[47] Large firms account for almost 80 per cent of the R&D performed in Canada[48] and recipients of the enhanced credit must be Canadian controlled, so foreign-controlled firms account for 46 per cent of R&D performed by recipients of the regular SR&ED investment tax credit.[49] Starting with the assumption that the required pre-tax rate of return on R&D to investors is 15 per cent[50] and calculating the required after-tax return using U.S. tax rates,[51] the required return net of Canadian taxes is 11.1 per cent. As a result, about five per cent (.46*11.1 per cent) of the subsidy provided to large firms accrues to non-Canadians.

ADMINISTRATION AND COMPLIANCE COSTS

The compliance cost estimates used in this paper were developed from a survey undertaken for the federal expert panel for the Review of Federal Support to Research and Development.[52] The survey indicates that applying for the subsidy and complying with the program requirements costs large firms 4.7 cents per dollar of tax credit received. The cost for small firms is 14.2 cents, which is three times the cost to large firms. Analysis of the data by Lester (2012) indicates that there is a substantial fixed cost in applying for the subsidy. For both large and small firms, fixed costs account for about two-thirds of total compliance costs.

The Canada Revenue Agency's operational budget for administering the federal SR&ED investment tax credit was approximately $57 million in fiscal 2018-19,[53] which represented 2.2 per cent of the value of the claims processed in that year. Information on administration expenses for claims by size of firm is not available. If processing costs were the only administrative expense the CRA incurred, the share of small firms in total administration expenses would be approximately equal to their share in the number of claims, which is 75 per cent. However, the CRA also incurs costs to validate claims; these efforts are likely to be allocated based on claim values, which are split roughly equally between small and large firms. In the absence of other information, I assume that small firms account for 62.5 per cent of administration costs. With this assumption, administration expenses amount to 2.7 per cent of claims made by small firms and 1.7 per cent of claims made by large firms.

---

47 Statistics Canada. Table 27-10-0335-01 Business Enterprise In-house Research and Development Expenditures by Country of Control. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2710033501.

48 See footnote 13.

49 Note that foreigners could have a minority equity position in Canadian-controlled firms.

50 This is the median private rate of return in seven recent studies reported in Kim and Lester (2019).

51 I am assuming that foreign investors have the same target rate of return on their world-wide portfolio, proxied by the after-tax return on US investments.

52 See Lester (2012) for details.

53 This information was provided by the Canada Revenue Agency in response to an Access to Information request.

The key parameters used in the benefit-cost analysis are presented in Table A2.

TABLE A2: KEY PARAMETER VALUES IN THE BENEFIT COST ANALYSIS (PERCENTAGE, EXCEPT AS NOTED)

	Small Firms	Large Firms
Administration expenses[1]	2.7	1.7
Compliance costs[1]	14.2	4.7
Federal effective subsidy rate[2]	31.7	11.3
Federal-provincial effective subsidy rate[2]	38.9	18.5
Spillover rate[3]	19	52
90% confidence interval	8 to 30	41 to 63
Pre-tax rate of return on R&D	--	15
After-tax rate of return on R&D	--	11.1
Foreign ownership share	0	46
R&D commercialization rate	65	73
Export intensity	10	63
Elasticities		
R&D demand	-1.4	-1.0
Demand for R&D intensive products	-4	-4
Supply of R&D-intensive products	4	4

1. Percentage of the subsidy provided
2. Percentage of total business R&D performed in Canada.
3. Reduction in production costs per $100 of R&D induced by the subsidy.

About the Author

John Lester is an Executive Fellow with The School of Public Policy at the University of Calgary. He is a former federal government economist who writes on public policy issues. John's last public service assignment was Director of Research for the Expert Panel Review of Federal Support to Research and Development. Prior to that, he managed the Tax Evaluations and Research Group at Finance Canada. Since leaving the public service, John has published papers with The School of Public Policy, the Canadian Tax Journal, Canadian Public Policy, the C.D. Howe Institute, and the Information Technology and Innovation Foundation. His research interests include cost-benefit analysis of tax incentives for business investment, particularly those related to R&D and innovation; government support for small business and entrepreneurship; and tax expenditure analysis.

ABOUT THE SCHOOL OF PUBLIC POLICY

The School of Public Policy has become the flagship school of its kind in Canada by providing a practical, global and focused perspective on public policy analysis and practice in areas of energy and environmental policy, international policy and economic and social policy that is unique in Canada.

The mission of The School of Public Policy is to strengthen Canada's public service, institutions and economic performance for the betterment of our families, communities and country. We do this by:

- *Building capacity in Government* through the formal training of public servants in degree and non-degree programs, giving the people charged with making public policy work for Canada the hands-on expertise to represent our vital interests both here and abroad;
- *Improving Public Policy Discourse outside Government* through executive and strategic assessment programs, building a stronger understanding of what makes public policy work for those outside of the public sector and helps everyday Canadians make informed decisions on the politics that will shape their futures;
- *Providing a Global Perspective on Public Policy Research* through international collaborations, education, and community outreach programs, bringing global best practices to bear on Canadian public policy, resulting in decisions that benefit all people for the long term, not a few people for the short term.

The School of Public Policy relies on industry experts and practitioners, as well as academics, to conduct research in their areas of expertise. Using experts and practitioners is what makes our research especially relevant and applicable. Authors may produce research in an area which they have a personal or professional stake. That is why The School subjects all Research Papers to a double anonymous peer review. Then, once reviewers comments have been reflected, the work is reviewed again by one of our Scientific Directors to ensure the accuracy and validity of analysis and data.

The School of Public Policy
University of Calgary, Downtown Campus
906 8th Avenue S.W., 5th Floor
Calgary, Alberta T2P 1H9
Phone: 403 210 3802

DISTRIBUTION
Our publications are available online at www.policyschool.ca.

ISSN
ISSN 2560-8312 The School of Public Policy Publications (Print)
ISSN 2560-8320 The School of Public Policy Publications (Online)

DATE OF ISSUE
January 2021

MEDIA INQUIRIES AND INFORMATION
For media inquiries, please contact Morten Paulsen at 403-220-2540. Our web site, www.policyschool.ca, contains more information about The School's events, publications, and staff.

DEVELOPMENT
For information about contributing to The School of Public Policy, please contact Catherine Scheers by telephone at 403-210-6213 or by e-mail at catherine.scheers@ucalgary.ca.

RECENT PUBLICATIONS BY THE SCHOOL OF PUBLIC POLICY

VULNERABILITIES AND BENEFITS OF MEGASCALE AGRIFOOD PROCESSING FACILITIES IN CANADA
https://www.policyschool.ca/wp-content/uploads/2020/12/AgriFood-Processing-Carlberg.pdf
Jared Carlberg | December 2020

CHALLENGES AND PROSPECTS FOR THE CPTPP IN A CHANGING GLOBAL ECONOMY: TAIWANESE ACCESSION AND CANADA'S ROLE
https://www.policyschool.ca/wp-content/uploads/2020/12/Canada-Taiwan-CPTPP-Stephens.pdf
Hugh Stephens | December 2020

SOCIAL POLICY TRENDS: UNEMPLOYMENT AND THE USE OF FOOD BANKS
https://www.policyschool.ca/wp-content/uploads/2020/12/Social-Trends-Food-Bank.pdf
Ron Kneebone | December 2020

ENERGY & ENVIRONMENTAL POLICY TRENDS: IS THE SITE C PROJECT WORTH ITS GROWING PRICE TAG?
https://www.policyschool.ca/wp-content/uploads/2020/12/Energy-Trends-Site-C-Project.pdf
Brett Dolter, G. Kent Fellows and Nicholas Rivers | December 2020

THE CANADIAN NORTHERN CORRIDOR: PLANNING FOR NATIONAL PROSPERITY
https://www.policyschool.ca/wp-content/uploads/2020/12/CNC-National-Prosperity-Fellows-et-al.pdf
G. Kent Fellows, Katharina Koch, Alaz Munzur, Robert Mansell and Pierre-Gerlier Forest | December 2020

FISCAL POLICY TRENDS: ANALYZING CHANGES TO ALBERTA'S CHILD CARE SUBSIDY
https://www.policyschool.ca/wp-content/uploads/2020/11/FPT-AB-child-subsidy.pdf
Rob Buschmann, Jennifer Fischer-Summers, Gillian Petit, Anna Cameron and Lindsay Tedds | November 2020

SOCIAL POLICY TRENDS: INCOME DISTRIBUTION TRENDS AMONG MEN AND WOMEN IN CANADA
https://www.policyschool.ca/wp-content/uploads/2020/11/Social-Policy-Trends-Female-Male-Incomes-2000-vs-2017-November-2020-1.pdf
Margarita Wilkins | November 2020

ENERGY & ENVIRONMENTAL POLICY TRENDS: THE HIDDEN COSTS OF A SINGLE-USE PLASTICS BAN
https://www.policyschool.ca/wp-content/uploads/2020/11/Energy-Trends-Single-Use-Plastics.pdf
Victoria Goodday, Jennifer Winter and Nicholas Schumacher | November 2020

ENERGY AND ENVIRONMENTAL POLICY TRENDS: CHEAP RENEWABLES HAVE ARRIVED
https://www.policyschool.ca/wp-content/uploads/2020/11/Energy-Trends-Renewables-Nov.pdf
Nicholas Schumacher, Victoria Goodday, Blake Shaffer and Jennifer Winter | November 2020

GOVERNANCE OPTIONS FOR A CANADIAN NORTHERN CORRIDOR
https://www.policyschool.ca/wp-content/uploads/2020/11/Governance-CNC-Koch-Sulzenko.pdf
Andrei Sulzenko and Katharina Koch | November 2020

CLIMATE CHANGE AND IMPLICATIONS FOR THE PROPOSED CANADIAN NORTHERN CORRIDOR
https://www.policyschool.ca/wp-content/uploads/2020/11/Climate-Change-CNC-Pearce-Ford-Fawcett.pdf
Tristan Pearce, James D. Ford and David Fawcett | November 2020

FINANCING AND FUNDING APPROACHES FOR ESTABLISHMENT, GOVERNANCE AND REGULATORY OVERSIGHT OF THE CANADIAN NORTHERN CORRIDOR
https://www.policyschool.ca/wp-content/uploads/2020/10/Funding-Approaches-CNC-Boardman-Moore-Vining.pdf
Anthony Boardman, Mark A. Moore and Vining, Aidan | October 2020

CROSS-CANADA INFRASTRUCTURE CORRIDOR, THE RIGHTS OF INDIGENOUS PEOPLES AND 'MEANINGFUL CONSULTATION'
https://www.policyschool.ca/wp-content/uploads/2020/10/CNC-Indigenous-Wright-final.pdf
David V. Wright | October 2020